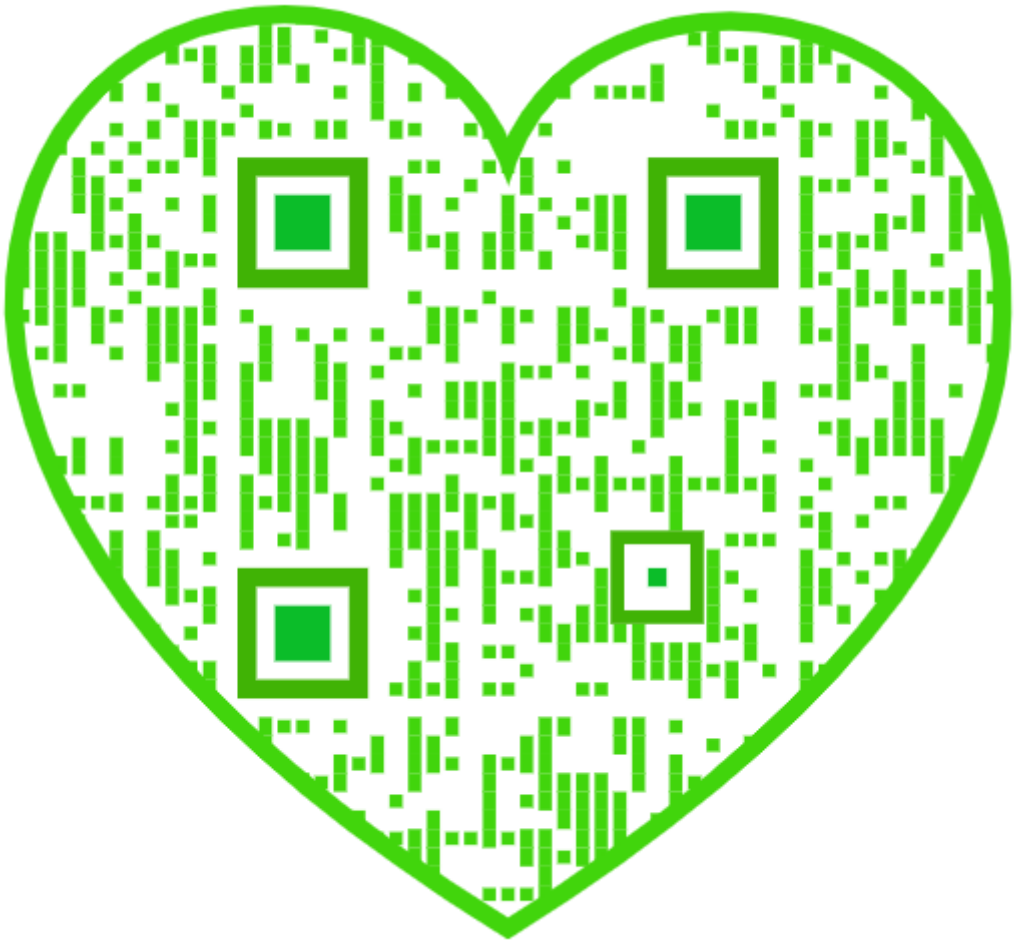

ITALIAN IRRIGATION

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ITALIAN IRRIGATION

BEING A REPORT ON THE

AGRICULTURAL CANALS OF PIEDMONT AND LOMBARDY

ADDRESSED TO THE HONOURABLE THE COURT OF DIRECTORS
OF THE EAST INDIA COMPANY

BY

R. BAIRD SMITH, F.G.S.
CAPTAIN OF ENGINEERS, BENGAL PRESIDENCY

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ABSTRACT OF CONTENTS.

PART III.

PRACTICE OF IRRIGATION IN NORTHERN ITALY.

CHAPTER I.

SYSTEMS OF MEASUREMENT OF WATER FOR IRRIGATION IN NORTHERN ITALY.

Page

Introductory remarks—varieties of measures in Italy, and difficulties created thereby—importance of a good measurement system to the agricultural interests of India—sketch of existing system there—measurement by area of irrigation, and by area of outlet—distinction to be observed between the unit of measure and the means of measurement—illustrated by reference to Art. 643 of the code of Charles Albert—measurement of water for irrigation in Parma and Placentia—in Modena and Reggio—comparison of the Modenese *macina* and the Piedmontese *ruota*—state of the question in Ferrara, Romagna, and Bologna, ... 3–12

SECTION I.—SYSTEM OF MEASUREMENT IN PIEDMONT.

Difficulty of the subject—the *ruota* of Piedmont—date of introduction—dimensions—volume in English measures—imperfections from variations of linear dimensions—examples of this—practical objections to the use of the *ruota*—the *oncia* of Caluso introduced by the engineer Contini—dimensions—volume—neglect of the essential conditions of the measure in practice—reintroduction of the *ruota* by Francesco Michelotti—modification thereof by Ignazio Michelotti—dimensions and volume of the *oncia* of Michelotti—*oncia* of the Novarese—dimensions and volume—imperfectious—the *ruota* of Novara—the *oncia* of Mortara—general conclusion regarding the ancient and local water-measures of Piedmont—the *modulo*—its dimensions and volume—method of issuing more than one *modulo*—forms of apparatus employed for measuring water in Piedmont—example with diagram—varieties of these in practice—general conclusion from the examination of the measurement system of Piedmont—formula—tables of the absolute and relative values of the different water-measures of the Sardinian states, ... 13–26

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SECTION II.—SYSTEM OF MEASUREMENT IN LOMBARDY.

Page

Water-measures of the different provinces of Lombardy — authorities quoted. 1. *Oncia* of the province of Lodi—dimensions—mixture of linear measures of Milan and Lodi in these—volume in English measures. 2. *Oncia* of the provinces of Cremona and Crema—dimensions and volume of the Cremonese *oncia*—example and diagram—descriptive details—imperfections—relation of the Cremonese measure to the *modulo magistrale*—historical details—*oncia* of Crema—dimensions. 3. *Oncia* of the province of Bergamo—circular in form—dimensions—imperfections. 4. *Quadretto* of the province of Brescia—form and dimensions—description by Signor Corboloni—defects of the system. 5. *Quadretto* of the provinces of Verona and Mantua—the form and dimensions of the *Quadretto Veronese*—want of fixed measures in the eastern provinces of the Lombardo-Venetian kingdom, ... 26-36

SECTION III.—MEASUREMENT SYSTEM OF THE MILANESE.

Essential conditions of a good measuring apparatus for water used in irrigation—elementary principles—*tavola parabolica* of De Regi—difficulties due to the various physical conditions of discharge through orifices—experiments of MM. Poncelet and Lesbros—views of Brunacci—practical results to be sought in an efficient system of measurement—principles on which the Milanese modulo is founded—application of these—numerical illustration—functions of the *paratoja*, or hydrometric sluice—fixed and variable elements of the measuring apparatus of the Milanese—the ancient *rodigine*, or wheel-measure of Milan—specific determination of water-measures in 1503—germ of the *modulo magistrale* to be traced in these—*modulo* of Giacomo Soldati introduced in 1572—repetition of the three fundamental conditions of the measure as prescribed by the magistracy of Milan—unit of measure established by Soldati—dimensions thereof—diagram of 1 *oncia*—diagram of 6 *oncie*—precautions to be observed in constructing the outlets—diagram of the *modulo magistrale*—descriptive details—analysis of the *modulo*—essential objects to be effected by it—modifications of form in practice—imperfections consequent thereupon—value of the *oncia magistrale* in English measures—variety of results according to different authorities—origin of these differences—relations of large and small outlets to quantity discharged by each—restriction of the size of outlets—mean value of the *oncia magistrale*—grounds on which Brunacci concludes that the *modulo magistrale Milanese* is the best form of measuring apparatus extant, and suggestions for its improvement—table of the values in cubic feet per second, of the different water-measures of Lombardy, ... 36–57

SECTION IV. — ON THE INTRODUCTION OF A UNIT OF MEASURE, AND A MEASURING APPARATUS, INTO THE IRRIGATION SYSTEM OF NORTHERN INDIA.

Existing information considered insufficient to warrant dogmatic views on the above subjects—methods of measurement at present employed in India. 1. By single outlets—descriptive details thereof. 2. By reservoir outlets—description and imperfections. 3. By wooden funnels or tubes. 4. By outlets from main water-courses—diagram illustrating the system—suggestions on the unit of measure for India—an outlet giving the nearest obtainable approximation to a discharge of one cubic foot per second, recommended for consideration — preliminary experiments held to be necessary—work done in irrigation by the unit above suggested—decimal division thereof recommended—

Page

experiments on areas irrigated by different quantities of water applied to different crops, and on different soils, suggested—deficiency of this kind of information in Italy—illustrations—hints on the form of measuring apparatus best adapted for India—propriety of restricting the number of these to one for each main water-course — general form of the *modulo magistrale*, with modifications suited to local peculiarities, recommended for use in India — the measuring apparatus and the head-works of chief water-courses to be constructed invariably at the expense of Government—the utmost simplicity recommended for the measurement apparatus attached to village water-courses—reasons for this—details suggested for consideration—probable results, 53–66

SECTION V.—ON MEASUREMENT OF WATER IN PIEDMONT AND LOMBARDY BY HORARY ROTATION (Orario).

Reference to the probability that this system of measurement may ultimately become necessary in India—periods of rotation—example—provisions in the civil code of Sardinia, for disputes connected with horary distribution of water—examples of problems connected with horary rotations, ... 66–74

CHAPTER II.

EMPLOYMENT OF WATER FOR IRRIGATION IN THE AGRICULTURE OF NORTHERN ITALY.

SECTION I.—SUMMER MEADOW IRRIGATION.

Local division of summer meadows—permanent and temporary meadows —subdivision of permanent meadows into summer and winter, or *marcite*—principles to be followed in adapting land for summer meadows —process of levelling—dimensions of the *ale* or planes—example in the province of Lodi — arrangements for irrigation and subsequent drainage—slopes — great variety of these in practice—operation of drainage channels—value of drainage waters—produce—value thereof—temporary or rotation meadows—rotation for five and six year periods—illustrations of the costs and returns from irrigated and unirrigated lands in Piedmont, and the province of Milan—proportion of gross returns to amount of rent—quantity of water necessary for common meadow irrigation—methods of estimating this—total area of irrigation, estimated at double the extent of the first watering with a given quantity of water—numerical illustrations—summary of results from experience in Italy and France, ... 75–86

SECTION II.—"MARCITE" OR WINTER MEADOW IRRIGATION.

Limited extent of winter irrigation in Northern Italy—contrast in this respect between the use of water in Italy and India—area of irrigation by a discharge of one cubic foot of water per second in these regions respectively—reference to Signor Berra's work on winter meadows—period during which water for winter irrigation is granted — different sources of the water employed—comparative values of the water thus procured — high temperature of the water of irrigation essential—

Page

illustration—advantages of using town sewerage water—of surplus water of irrigation—list of waters in the order of their utility for winter irrigation—preparation of the land—arrangements for irrigation and drainage—diagram of a *marcite* field—descriptive details—employment of the *raggia* or earth-scoop—carriage-ways—statement of expenses—manures of various kinds used for winter meadows—quantity of water required—memorandum on the subject by Signor Brioschi—produce of winter meadows—statement of expenses and returns—net returns and rent per acre under different circumstances, 86–100

SECTION III.—RICE CULTIVATION IN THE IRRIGATED DISTRICTS.

Division of rice-cultivation into permanent and temporary—restriction of permanent rice-lands to marshy localities—rotation with rice introduced—nature of soil best suited for rice—arrangements for irrigation—details of culture—produce of rice-lands—numerical illustration—value of returns—quantity of water necessary—difficulty of estimating this—cost of irrigation per acre—some statistical details, ... 100–107

SECTION LAST.—ON THE USE OF "FONTANILI" OR SPRINGS FOR IRRIGATION.

Distribution of water bearing strata throughout the irrigated region of Northern Italy—illustration—indications of the existence of springs—process of searching for water—depth of excavation for the heads—means adopted for protecting the jets or "eyes" of the springs—formation of the spring-heads—means of recognising the positions of the "eyes"—irrigation channels—money value of spring water illustrated—influence of springs on the volumes of canals—illustrations—approximate estimates of the entire quantity of water derived from springs in Northern Italy, and used in agriculture—some considerations on the distribution of property as affecting the irrigation system of Northern Italy, ... 108–114

PART IV.

LEGISLATION OF IRRIGATION IN NORTHERN ITALY.

INTRODUCTORY REMARKS—HISTORICAL SUMMARY OF THE PROGRESS OF THE LEGISLATION OF IRRIGATION IN NORTHERN ITALY.

Recognition of the laws of irrigation as common customs long before their embodiment in any written form—their appearance in the statutes of Milan dated 1216—original date carried back by some authorities to the tenth century—abstract of the ancient statutes affecting irrigation—leading principles established thereby—progress of the legislation of irrigation—new statutes of Giovanni Galeazzo

Page

Visconti, published in 1396—application of the right of passage to the canal Martesana by Francesco Sforza in 1457—regulations established by Bianca Maria Visconti—legislation on irrigation by Louis XII. of France in 1502—laws established by the Venetian senate in 1455—details of these—precautions taken to reconcile the right of passage with the rights of property—constitutions of Charles V., published in 1541—extension of these to the provinces between the Ticino and the Sesia, now belonging to Piedmont—ancient legislation in the Sardinian States—statutes of Victor Amadeo and Charles Emanuel III., published in 1770—extracts from these—differences between the ancient legislation of Piedmont and Lombardy—improvements in the administration of the canals of the latter country during the reign of Maria Theresa of Austria—legislation on irrigation during the period of the Cisalpine Republic and the Kingdom of Italy—Austrian civil code published in 1816—its imperfections, and the consequent reintroduction of the laws of the Kingdom of Italy for irrigation—progress of legislation in Piedmont to the publication of the existing code of Charles Albert in 1837—irrigation now regulated by this in Piedmont, and by the laws of the 20th April 1804, and the 20th May 1806, in Lombardy—quotation of authorities, ... 117-130

CHAPTER I.

LEGISLATION OF IRRIGATION IN LOMBARDY.

SECTION I.—RIGHT OF PROPERTY IN WATER.

The right of property in all running water reserved to the state—growth of this right illustrated—modes in which the right is exercised by the state in disposing of the waters for irrigation or other purposes. 1st, By absolute sale. 2d, By perpetual lease at fixed annual rents. 3d, By temporary lease at fixed annual rents—influence of the system of absolute sale on the agricultural prosperity of the country—circumstances which have rendered this influence beneficial on the whole—reflections on the introduction of the principle into the irrigation system of Northern India—characteristic differences between the conditions of the two countries—preference given to the system of permanent leases—respect for prescriptive rights to water in Lombardy—conditions of leases on the great canals of the Ticino and Adda—extracts from the law of 1806 defining the right of property in running water, and the manner in which the government exercises it, ... 131-146

SECTION II.—RIGHT OF PASSAGE IN LOMBARDY.

Origin of the right—influence of the Naviglio Grande, and its consequences—first rude form of compensation for land occupied by water-courses from the canal—reappearance of the same method in Northern India—disputes between the proprietors of land and the consumers of water from the Naviglio Grande—establishment of limitations to the right of passage—the right of passage regarded as a simple servitude—introduction of protective distances between water-courses belonging to different proprietors—obligation to select the line of least damage—extracts from the Austrian civil code affecting the right of passage for water—imperfections of the code—litigation consequent thereon—example of this—decisions of the different tribunals—final decision of the Aulic Council of Vienna, re-establishing in full vigour the provisions of the

Page

laws of 1804 and 1806 regarding the right of passage—notification of the same in 1825—extracts from the law of the 20th April 1804—extract from the law of the 20th May 1806—restriction of the use of pre-existing channels to the cases of public canals only—the right of passage applicable to *colature* or surplus waters of irrigation—general freedom of the circulation of water—influence on this of the qualifications of the engineers of Lombardy—their intimate connection with the questions arising out of the right of passage, ... 146-159

SECTION III.—MEASUREMENT AND DIVISION OF WATER.

Want of any general rule for the measurement and division of water in Lombardy—articles of the law of the 20th May 1806 affecting this question—prevalence in each province of its own customs—illustration of the general rules observed for measuring and distributing water—modification in special cases—contracts for meadow and rice irrigation adverted to—disposal of the surplus waters, ... 160-167

SECTION IV.—DERIVATIONS OF WATER FROM SPRINGS.

Protective distances for springs as established by the ancient statutes of Milan—provisions of the law of the 20th April 1804 on protective distances—of the law of the 20th of May 1806, on the same subject—distribution by horary rotation subject to special agreements in each case, ... 167-169

SECTION V.—GENERAL ADMINISTRATION AND POLICE.

Local associations for purposes of irrigation—ancient origin of the associative principle—organisation at present founded on the provisions of the laws of the 20th April 1804, and the 20th May 1806—extracts from these laws—1. Organisation of the associations. 2. Details of superintendence. 3. Details of works. 4. Distribution and realisation of expenditure. 5. General arrangements—examples—association of the river Olona—historical sketch—regulations—association of the river Lambro—edict of 1756 republished in 1837—edict of the 20th December 1782—beneficial operation of the associative principle in Lombardy—illustration of the method of electing the representative councils of associations in the case of the Muzza Canal—unsatisfactory results in the case given — regulations of irrigation in the frontier provinces of Verona and Mantua—historical details—treaty of Ostiglia in 1764—tenth appendix to the treaty containing the final regulations —administration and police of irrigation in the province of Mantua—edict of the 24th December 1781—tariff of prices of water in Mantua —sketch of the organisation of the canal department in Lombardy—the associative principle recommended for adoption into the irrigation system of Northern India, ... 169-219

SECTION LAST.—SANITARY REGULATIONS.

Conditions of irrigation as connected with malaria—sanitary relations of rice and meadow cultivation—general conviction of the insalubrity of rice-culture—doubts regarding that of summer and winter meadow cultivation—historical sketch of the progress of sanitary legislation in Lombardy—first regulations in 1575—nature of these—establishment then of the protective measures ever afterwards employed—protective zones round inhabited places—limitation of area of rice-culture—vari-

Page

ations in the extent of the protective zones—law of the 8d February 1809—modification of the same in 1812—formalities to be observed in applying for permission to establish new rice-lands—discussion of the question regarding the salubrity or otherwise of meadow irrigation—quotation from Signor Berra's work on this subject—statistical details—general conclusions from these — importance of general, and especially local, drainage to the salubrity of irrigation—relations of the question to the existing circumstances of India—sanitary regulations for the city of Milan—general sewerage arrangements—Association of the Sevese—1. Organisation—2. Officers of the association and their duties—3. Formation of the list of contributors, and regulations connected therewith—4. Works connected with the drainage channels—5. Distribution of the expense and scale of payments — 6. General arrangements—limitation of the details in this Section to irrigation only, ... 219-247

CHAPTER II.

THE LEGISLATION OF IRRIGATION IN PIEDMONT.

SECTION I.—ON THE RIGHT OF PROPERTY IN WATER.

The right of property in all running water reserved, as in Lombardy, to the state — patent of the 29th May 1817 — instructions of the 14th February 1828 regarding grants of water—Articles of the Civil Code of Sardinia regarding rights of property in water—Articles of the Code defining private rights to water—remarks on these—respect shown to rights acquired by long usage—reference to local customs—limitation of private rights to water—illustrative anecdote—supervision and control exercised by the state over the private canals between the rivers Sesia and Ticino—rejection by the legal tribunals of the claims of proprietors of private canals to the absolute right of property in the waters thereof—illustrations in the cases of the Canals Mora and Biraga—rejection by the Commission on the Civil Code of the *Diritto d'Insistenza* — application of foregoing details to the canals of India, ... 248-263

SECTION II.—ON THE LEGAL RIGHT OF PASSAGE FOR WATER IN PIEDMONT.

Articles of the Civil Code regulating the right of passage for water belonging to private individuals—remarks on the same—the right of passage is a simple servitude—Articles of the Code defining the same—universal application of the right of passage in Piedmont—confirmation thereof by public opinion—arrangement regarding the right of passage through pre-existing canals or water-courses — protection of landed proprietors against fictitious demands for rights of passage—details of compensation for land occupied—reasons assigned for the payment of an excess of one-fifth over the true value of the land—provisions regarding the increase of the volume of water carried by canals having a servitude of passage—canals, when declared works of public utility, brought under another series of provisions—Articles of the Civil Code relating thereto—special law on works of public utility, dated 6th April 1839—abstract thereof—ministerial instructions of the 12th June 1839—abstract thereof—distribution of canals into two classes as connected with the right of passage—application of the right of passage in the irrigated region of Northern India, ... 263-279

SECTION III.—ON THE MEASUREMENT AND DISTRIBUTION OF WATER FOR IRRIGATION.

Page

Methods of distribution in common use throughout Piedmont—1st, Distribution according to *Use*—2d, Distribution according to *Time*—3d, Distribution according to *Quantity*—Articles of the Civil Code affecting these methods—remarks on these—importance attached to agreements between interested parties—limit of error in volumes of water, as defined by the Code—limits by usage—limits when special service is the basis of agreements—limits when time is introduced—varieties of outlets regulated by time—periods during which rights to water by time exist—provisions for regulating horary rotations—for distribution by day and night—on fête days—disposal of the *coda* or tail of the water in horary distributions—rights to leakage and spring waters defined—interchanges of periods of rotation among the employers of a common channel—provisions for regulating the effects of deficiencies of supply in the canals—Articles of the Civil Code relating thereto—remarks on the same—satisfactory character of the Piedmontese legislation on the present subject adverted to, and commended to careful study, ... 280-295

SECTION IV.—ON PROTECTIVE DISTANCES BETWEEN WATER-COURSES, DISPOSAL OF DRAINAGE WATERS, EXTINCTION OF SERVITUDES CONNECTED WITH WATER, AND RULE OF SUMMARY POSSESSION.

Physical conditions which modify the action of filtration, and affect consequently the limits of protective distances—articles of the Sardinian civil code regulating these—results of experience on this subject in Northern Italy—conclusions—opinion of Giovanetti—reference to the views of Romagnosi—recommendation of a maximum and minimum of protective distance—provisions for the disposal of the drainage waters of irrigation—articles of the civil code relating thereto—necessity for some like provisions in Northern India adverted to—articles of the code regulating the extinction of servitudes connected with water—rule of summary possession, ... 295-304

SECTION V.—GENERAL ADMINISTRATION AND POLICE.

Extracts from the regulation of the 29th May 1817—regulation of the 10th September 1836, for the administration of the royal canals of irrigation—instructions of the agency-general of finance to the officers of the royal canals, &c., under date the 30th September 1838—duties of the director of the canals—of the engineer-inspectors, assistants, and guardians of the canals—provisions of the penal code of Sardinia for the protection of irrigation works and water, ... 304-318

SECTION VI.—SANITARY LEGISLATION.

Recent sanitary legislation of Piedmont—report of the commission of the senate on a provisional law for regulating rice-cultivation—deficiencies of data whereon to base definitive legislation—historical sketch of the progress of sanitary legislation in Piedmont—first enactment on the subject in 1608—provisions of this—edict of 1663—protective zones established thereby—edicts of 1669—of 1697—of 1728—sanitary arrangements in the provinces of Vercelli—of the

Page

Lumellina—of Novara—acts of 1792 and 1793—introduction of the provisions of the law of the Kingdom of Italy, under date the 9th February 1809, into the provinces between the Sesia and the Ticino—patent of 1792 re-established for the whole kingdom of Piedmont in 1814—proceedings of the special commission on irrigation formed in 1815—conclusions drawn from the historical summary—provisions of the project of the law recommended by the senate in 1851—remarks by M. Giovanetti on the subject of sanitary legislation—unsatisfactory condition of the question in Piedmont—necessity for great caution in legislating definitively upon it adverted to, ... 319-332

CONCLUDING REMARKS.

ON THE LEGISLATION OF IRRIGATION IN NORTHERN INDIA.

Reasons assigned for its existing imperfections—act VII. of 1845 on the administration and police of canals of irrigation in Northern India—proclamation of the lieutenant-governor of the north-western provinces giving effect to the act in detail—administrative provisions established by the act and proclamation — comparison with the legislation of Northern Italy—deficiencies in the legislation of irrigation in India—the method of supplying them suggested—police of irrigation in India—its imperfections—revision of the entire question recommended—sanitary regulations of canal irrigation in India—proceedings of the committee appointed to investigate the relations of irrigation to the public health—the employment of the "spleen test"—explanation of it, and limitations necessary in estimating its value—method of applying it in practice—degrees of the test scale—conclusions warranted by the facts ascertained—protective measures connected with the use of irrigation—conclusion—reflections on the importance of irrigation in India as a material and moral agent in improving the condition and prospects of the country and its population, ... 333-364

PART III.

PRACTICE OF IRRIGATION IN NORTHERN ITALY.

THE IRRIGATION SYSTEM

OF

NORTHERN ITALY.

PART III.

PRACTICE OF IRRIGATION IN NORTHERN ITALY.

INTRODUCTORY REMARKS.

THE curiously fragmentary state of society in Italy forces itself on a traveller's notice, not only in matters of feeling, but more strikingly, because more tangibly, in matters of fact. A remarkable illustration of the latter view is found in the infinite variety of measures of all kinds in use throughout that part of the country which is more especially the object of remark at present. It seems as though not only every great division of the country, but every small district or town, and even in some cases the pettiest villages, had established each its own independent system, to the utter confusion of any one who has come under the necessity of seeking information regarding such details as are thereby embraced. I have before me, at this moment, a folio volume of more than one hundred and fifty pages of tabulated materials, referring solely to the variety of weights and measures in use throughout

the small kingdom of Piedmont alone. The confusion naturally arising from this extraordinary variety has led to vigorous efforts on the part of the governments to replace the local measures by a well-defined and common system; and it was to facilitate this that the volume I have referred to was issued by the Sardinian minister of agriculture and commerce, who has caused, at great expense of labour, the whole of the local measures to be reduced to their equivalents in the French decimal system. Of course, an article of so much social value as water for irrigation forms no exception to the general rule, and the measures in use for its distribution exhibit the same variety as characterises those for area, capacity, weight, and linear dimensions. It is not my intention to enter into any very minute details of the different water measures, but some information regarding them is necessary, and this I have sought for among the best accredited authorities on the subject, references to which I give below.*

There is, perhaps, no branch of the practice of irrigation so important to the interests of India at this moment as the establishment of a satisfactory unit of measure for the distribution of water, and the introduction of such a form of apparatus as will insure the maintenance of this unit within reasonable limits of error. With the prospect before us of a system of irrigation canals developing itself over the entire surface of the

* "Tavole di Ragguaglio degli Antichi Pesi e Misure, &c. &c., publicate del Ministero di Agricoltura e Commercio. Turin, 1849." "Appendix on the Units of Measure for Running Water, pp. 37-42." "Codice Civile," published in 1837 for the kingdom of Sardinia. "Bruschetti," history of irrigation in the Milanese. "De Regi, Uso della Tavola Parabolica per le Bocche d'Irrigazione. Milan, 1804." "Tadini, del Movimento e della Misura della acque Corrente. Milan, 1816." "Brunacci, Sulla dispensa delle acque. Milan, 1827." "Turazza, Trattato di Idrometria. Padua, 1845." "Colombani, Manuale Practico di Idrodinamica. Milan, 1845"—numerous MS. notes.

North-Western Provinces and the Punjaub, accompanied, as it advances towards completion, by a gradually increasing demand for the water, and a continually expanding area of cultivation entirely dependent for the security of its products on the supplies furnished by the canals, it is self-evident that the interests both of the government and the agricultural community require that an article so certain to rise in value should be subjected to just, simple, and well-understood regulations. Under existing circumstances, water is issued for irrigation in India under two different systems : 1st, By area irrigated—*i. e.*, at certain rates per acre, which vary both with the nature of the crop irrigated and the facilities for irrigation ; and 2d, By fixed outlets—*i. e.*, at certain rates per square inch of outlet, which also in practice vary considerably under no determinate rule, but according to local circumstances and the discretion of the chief officers of the department.

Now, as regards the system of charge for water by area of irrigation, the defects are almost self-evident. The lands irrigated vary annually—I might say half-yearly—in extent and position, hence the necessity for annual or half-yearly measurements by government officers to protect the interests of the state ; and hence, also, constant interference with the cultivators, and no small amount of fraudulent collusion between them and the subordinate officials to whom the duty of measurement is intrusted. The variation of the charge with the nature of the crop has farther the prejudicial effect of checking the extension of the more valuable products, or of facilitating evasion of the government demand by the substitution, in concert with the native officials, of the inferior for the superior crops. It is found, too, that under this system agriculture becomes to a certain extent precarious, for the temptation to trust to the chances of rain constantly lead the culti-

vators to defer irrigation so long, that their crops are seriously injured; and as the hope of a present saving is very frequently more powerful than the fear of a prospective loss, a sort of spirit of gambling is generated.

It is a step in advance to fix the dimensions of the outlet, and to regulate the charge by the superficial area thereof, leaving to the cultivator the unrestricted use of the volume of water thus supplied to him. But it is evident that to bring this system within legitimate limits, and to insure for it that degree of exactitude which is absolutely essential to a good arrangement for the issue of water, much more is necessary than the mere fixing of the superficial area of the outlet. Our historical sketch of the canals of the Milanese furnishes abundant proof of the imperfections of such a method in the simple form in which it is now employed in India, and of the impossibility of securing just and satisfactory results by its employment without additional precautions. The nature of these precautions, as determined by long experience in Northern Italy, we shall now proceed to show; and when they are all placed before us, we shall be able to indicate, with better effect than we can at present, those among them which appear best calculated for introduction into our Indian system.

In any system of measurement of water for irrigation, there are two distinct ideas involved, which it is desirable to define clearly, and to keep separate in the mind. There is first the idea of a unity of measure, apart altogether from the means which may be taken to insure its application in actual practice. Considerations of expediency will determine, in different localities, the special selection of this unity. It is sometimes the quantity of water which issues from an opening of fixed dimensions, with or without a certain pressure; at other times it is

the quantity of water which irrigates a given area of land under certain fixed conditions, and so on in different terms under different circumstances; for while one unit might suit the agricultural conditions of Italy, another might better suit those of India. The second idea involved in a measurement system is that of the special apparatus by which the volume of water, as defined in terms of the established units, is measured and issued. The forms of this apparatus depend, in principle, on purely scientific considerations. They are determined by the known principles of hydraulics, and are independent of those social or agricultural relations which influence the establishment of the unit of measure itself. The necessary separation between these two ideas is distinctly indicated in the civil code of Sardinia, the 643d article of which establishes very clearly and precisely a legal unit of measure for running water, while it leaves undetermined, as being a matter which must vary with the progress of science, the special form of edifice which is to be used in the practice of distribution. The terms of the article may be given to illustrate my meaning:—

"Art. 643. For new grants of water, wherein a certain constant quantity of running water shall be agreed upon and expressed, otherwise termed grants from fixed outlets, (*concessioni à bocca tassata*), the quantity conceded ought to be expressed in all public acts in relation to the 'module of water' (*al modulo d'acqua*).

"The measure, or *modulo*, is that quantity of water which, under simple pressure, and with a free fall, issues from a rectangular, quadrilateral opening, so placed that two of its sides shall be vertical. This outlet shall have a breadth of (7.874 inches) two decimetres, and a height of (7.874 inches) two decimetres. It shall be opened in a thin wall (or plate-*parete*), against which the water

stands, with its upper surface perfectly free, at a constant height of four decimetres (15.748 inches) above the lower edge of the outlet."

How the mechanical arrangements for fulfilling the conditions involved in this legal definition of the Piedmontese new module are to be worked out, is left to the skill of the engineers employed—varying according to private agreement in each case. Though the omission of a form of measuring apparatus has been censured, and has given rise to very lively controversy among the lawyers and engineers of the country, I am disposed to think that the framers of the code were judicious in fixing only the unit of measure, and providing as they have elsewhere done for unavoidable imperfections in the actual measurement, by barring all right to action unless the excess or deficiency complained of shall exceed one-eighth of the total volume specified in the grant (Art. 641). Such a margin will in practice be found to cover the probable errors of most forms of measuring apparatus now in use.

What the unit of measure, or the module, for Indian irrigation should be is a delicate and difficult question, scarcely, in my opinion, to be satisfactorily solved, in the existing state of our information on the subject; for hitherto we have been so busy in creating the grand framework of our canal system, that we have not had either time or opportunity for entering on the minuter questions connected with it. When, however, the details of Italian experience have been reviewed, perhaps some useful hints may be gleaned from them.

As might be anticipated from the limited development of irrigation within them, the States on the right bank of the Po present the rudest and most elementary forms of measuring apparatus. The memoir of Brunacci, *Sulla Dispensa delle Acque*, furnishes some details connected

with the modules of these districts, which it may be interesting to give here, as introductory to the more matured systems of Piedmont and Lombardy.

In the states of Parma and Placentia we find one of the most imperfect systems of measurement still in use. Quoting from the *Architettura Idraulica* of Barattieri, Brunacci says: "In these provinces, the sole unity of measure for the water of a canal is that quantity which flows in a channel having an area equal to 108 square inches, without fixed conditions either as regards depth, or breadth, or slope of bed, the sole essential prescribed being the area of section just stated." Under ordinary circumstances it is, however, usual to make the dimensions of the outlet 12 inches in height, and 9 inches in breadth; but as there is no established rule on the point, and as the same area of section may be obtained by at least ten combinations of dimensions, viz., 54 by 2, 36 by 3, 27 by 4, 18 by 6, and 12 by 9, with the converse arrangements of these numbers, it is very evident that extreme irregularity must be the result. It is well known, farther, that with variations of the heights and perimeters of outlets, the discharges vary materially; and as in each of the preceding cases both of these elements of calculation show important differences, the unity becomes of a very indefinite kind. By natural consequence, recourse is had in all important cases to the established and more definitive measures of other countries, and more especially to the module of the Milanese.

In the provinces of Modena and Reggio, the unit of measure is one which seems to have been the most widely spread of all during the ruder periods of irrigation. It is locally termed a *Macina*, and supplies the quantity of water necessary to drive the wheel of a corn-mill. It is the same measure which we find in the irrigated districts

of the Pyrenees under the term *Moulan*; in Piedmont it occurs as the *Ruota d'Acqua*; and in Lombardy as the *Rodigine*. It was in fact the first rude idea of unity likely to occur to an agricultural people commanding the use of water both for irrigation and motive power. Its value is of course extremely vague, but it is usually held to be the quantity of water issuing from an opening one *braccio* (equal to nearly 19.65 inches) square. There are no conditions established for fixing the pressure or the linear dimensions when the volume exceeds a single *macina*, so that it would be vain endeavouring to determine the real discharge. The dimensions of the macina of Modena are nearly the same as those of the ruota of Piedmont; and as the conditions of the latter are tolerably well fixed, its value will give us at least an approximate idea of that of the Modenese unit. The Sardinian engineers value the ruota at very nearly 12 cubic feet per second, and this may be assumed to represent the volume of the macina also—that is, supposing the water in both cases to issue at the surface level, and consequently without pressure. Though this may be generally, it is undoubtedly not always, the case, as in certain ancient grants expressed in *macine* the height of water above the upper edge of the outlet rises to 10 local inches, or nearly 13.72 English inches. It is very clear, therefore, that it is impossible to attach any precise value to this unit.

The macina is occasionally subdivided into nine parts, the volume of each being measured by a square outlet, having each side 6.68 English inches in length; but, strangely enough, this measure is equally indefinite as regards the pressure under which the discharge from it takes place, and its value cannot therefore be correctly determined.

In Ferrara and Romagna, the torrential character of the streams limits so much the application of their waters

to agricultural purposes, that no fixed system of measurement has arisen. In the province of Bologna, however, there is a canal of considerable size employed both for navigation and irrigation. Its supply, being derived from streams rising on the northern slope of the Apennines, is extremely precarious, and in summer the channel becomes nearly dry; hence the rules for measuring the water furnished by it are necessarily temporary and special. When grants are made, the pontifical engineers determine at discretion, and according to the local peculiarities of each case, the conditions which must be observed. In general, the outlets are simply openings in the bank of the canal, of variable dimensions, and supplied with sluices, which are regulated by *custodi*, or guardians, under orders prescribed by the engineers. The sole general rule for the principal canal above alluded to is, that the discharge from the irrigation outlets must be so limited as not to interfere with the navigation. In 1658 the Cardinal Farnese ordered that the lower sills of all the outlets should be made of stone, and raised three Bolognese feet above the level of the bottom of the canal; while each opening should be supplied with a sluice to regulate its discharge. This order was renewed in 1749, 1757, and 1793, by various cardinal-delegates, and finally in 1805 by the prefet of the department. In 1811, the canal Torbido, near Bologna, was subjected to regulation; and as great confusion had up to that time prevailed in all points connected with measurement of the water, the prefet ordered that the standard should henceforth be the quantity of water issuing from a square opening having sides of 6.68 English inches; but as this was the only prescription he thought fit to make, he did not much improve matters.

The topographical features of Central and Southern Italy are too generally unfavourable for irrigation to

have led to the introduction there of any well-defined system of measurement; and though in Tuscany, in the States of the Church, especially in the Pontine Marshes, and in Naples, there are irrigated tracts of considerable extent, I do not find, from the Italian authors on the subject, that any precise rules are in force throughout these territories. These brief introductory details show the infancy, as it were, of the measurement system, and represent that stage at which we have arrived in our Indian practice; for we are as yet scarcely, if at all, in advance of the better defined among the methods just described, and much in arrear of the best of those, to the account of which we may now proceed.

CHAPTER I.

SYSTEMS OF MEASUREMENT OF WATER IN NORTHERN ITALY.

SECTION I.

SYSTEMS OF MEASUREMENT IN PIEDMONT.

For the subsequent details of the measurement system of Piedmont, I am indebted to various original authorities, and I believe the results may be regarded as generally trustworthy. The different dimensions have been reduced throughout to English equivalents, and I have endeavoured to secure as much accuracy as was possible. But those who are best acquainted with the present state of hydraulics know best that allowances must be made for inevitable difficulties and imperfections in treating such a question as the present, in which all the results arrived at must still be regarded as only approximate.

I. THE RUOTA OF PIEDMONT.

For several centuries after the first introduction of the modern system of irrigation into Piedmont, no special unit of measure for running water was employed. Certain ancient documents referred to by Brunacci (p. 31),

establish the fact that it was first in 1474 that a special measure was adopted on the canal of Ivrea. An opening of a foot square in the measure of the country seems to have been the earliest unit employed; but as no determinate pressure was specified, this early form was no doubt exceedingly imperfect. About the middle of the sixteenth century, however, the element of pressure was introduced and clearly defined. In the Vercellese, and on the canal of Caluso, water was then issued in terms of *ruote*, or *wheels*, each of which was the quantity passing through a square opening of one foot, the upper edge of the outlet being what is locally termed *a fior di acqua*, or level with the surface of the water of the canal or reservoir, the discharge hence taking place under no pressure. The foot above referred to is the *Piede Liprando*, and measures 20.043 English inches. The Piedmontese foot is divided, like our own, into 12 *oncie*, or inches, and the superficial area of the ruota was consequently 144 local square inches. The somewhat incongruous employment throughout the irrigated districts of Northern Italy of the term *inch* at once as a linear, superficial, and water measure, is apt to lead to a little confusion; but a moment's consideration will serve to indicate the special meaning of the term in each case.

The volume discharged by the *ruota* is estimated by the Piedmontese engineers at 12.05 cubic feet per second. But into this determination there enters an element of error which local estimates do not take account of. In employing the *ruota* as a regulating measure, reference is made solely to its superficial area—144 square inches constituting a *ruota*, however this area may be obtained; or, in other words, the measure under remark is imperfect, because no fixed form is prescribed for it. The following short table illustrates my meaning:—

Linear dimensions applicable to a ruota. Height.		Breadth.		Fixed superficial area of a ruota.	Perimeters.
12	×	12	=	144	(12 + 12) 2 = 48
16	×	9	=	144	(16 + 9) 2 = 50
18	×	8	=	144	(18 + 8) 2 = 52
36	×	4	=	144	(36 + 4) 2 = 80
48	×	3	=	144	(48 + 3) 2 = 102
72	×	2	=	144	(72 + 2) 2 = 148

A glance at these figures will show the heights varying from 1 to 6, and the perimeters from 1 to 3, while the superficial area remains constant. To ascribe a fixed value to a measure thus variable in the most important elements which enter into the calculation of discharge, is impossible. That such variations are not merely possible, but have actually occurred, admits of documentary proof. In 1579 the dukes of Savoy and Mantua entered into an agreement regarding an irrigation outlet from the canal of Crescentino. In the papers connected with this transaction, a *ruota* is defined to be that quantity of water which passes without pressure through an opening 9 inches high by 16 inches wide, being an area of 144 square inches. Again, in 1764, in a grant made to the Count of Massino of three *ruote* of water from the canal of Caluso, the dimensions given to the outlet are 12 inches in height and 36 in breadth, or for each *ruota* 12 inches by 12. Various outlets with greater contrasts of dimensions are to be seen on the different canals, and show clearly that the *ruota* is too indefinite to constitute a good unit. Two principal considerations support this opinion :—1st, Outlets equal only in sections, but with different heights, have their centres at unequal depths below the surface of the supplying canal, and the water consequently issues from them under different pressures ; and 2d, The inequality of the perimeters necessarily modifies the contraction of the vein of water in passing

through the outlets. These are errors of principle, but extreme inconvenience in practice arises from the peculiarity of the *ruota* in having, as essential to its definition, no head of water or pressure over the upper edge of the opening. To expect perfect constancy in the surface-level of any canal of irrigation is a delusion. It inevitably varies, not only with the variations of the level of the supplying river, but with the ebbs and flows of demand for water in the interior of the canal itself. Hence the essential condition of the *ruota*, that the upper edge of the outlet should be *a fior d'acqua*, is almost impossible in practice. The discharge from orifices having a certain head of water, as is the case with all the best measures of Northern Italy, varies, of course, with variations of surface-level; but it is very palpable that in such cases the differences are much less than when the standard measure commences with no head whatever. The *ruota* is, in fact, the only measure in extensive employment which has the characteristic adverted to, and the practical inconvenience is remedied by special agreements, in which, contrary to the rigid idea of the measure, the element of pressure is actually introduced. Throughout the Vercellese I found the modules dispensing water by *ruote* quite as often with heads of water as without them.

I have already mentioned that it was in 1474 that the first trace of a unit of water-measure appears in Piedmont. The imperfect form then introduced continued to be employed with the modifications just indicated till 1730, when, by a decree of Charles Emanuel, duke of Savoy, the legal measure of water in Piedmont was denominated the *oncia*, and the volume thus termed was that obtained from a rectangular outlet having a constant height of 4 linear inches, with a breadth of 3 inches, and a head of water of 2 inches

above the upper edge of the outlet. This measure is locally termed

II. THE ONCIA OF CALUSO,

from its being employed very extensively on the canal of that name. It was first introduced by the engineer Contini, director-general of the royal canals, and is merely a copy of the *inch* of the Milanese as regards dimensions and pressure, except that the linear measures of Piedmont are employed instead of those of Milan.

The *oncia* of Caluso has the following dimensions in English measures—(1 oncia = 1.68 inches English :)—Height, 6.72 inches; breadth, 5.04 inches; pressure, 3.36 inches; discharge, according to the official estimate, 0.85 cubic feet per second. Such are the theoretical conditions of this measure, but it would be a great mistake to suppose that they are observed in practice. There is scarcely a single outlet regulated in terms of the *oncia* under notice in which the above limits are observed. The pressure is invariably greater than it ought to be, and by consequence the discharge is also in excess. For reasons best known to parties on the spot, these abuses are tolerated, though occasional efforts have been made to correct them.

One of the strangest of these was the re-introduction, at the close of the eighteenth century, by Francesco Dominico Michelotti, an eminent Piedmontese hydraulician, of the ancient and most imperfect measure by *ruote*. This was certainly an act of extreme folly, and, fortunately, the resistance to the system was such that very few outlets were granted in terms of this revived measure.

In 1800, however, Ignazio, the son of F. D. Michelotti,

having become director-general of the royal canals, determined to introduce a modification of his father's plan. The manifest inconveniences of having outlets level with the surface of the water in the canal of supply, induced Ignazio Michelotti to adopt an outlet, giving with a head of pressure the same discharge as the *ruota* of his father. He calculated that a rectangular opening, 4 Piedmontese inches high, 3 wide, with a pressure of 4 inches above its upper edge, should give a volume equal to 1 inch, or the twelfth part of the new *ruota*, being 0.98 cubic feet per second. In point of fact, however, while the *inch* of F. D. Michelotti is 0.98 cubic feet, that of Ignazio is, when correctly calculated, equal to 1.02 cubic feet per second. Hence the conversion of outlets, regulated according to the former, into others having the dimensions of the latter, operated to the disadvantage of the State in giving larger volumes than were just. This circumstance checked the extensive introduction of the *oncia* of Ignazio Michelotti, which had in truth no special recommendation over the more ancient form of Contini.

III. ONCIA OF THE NOVARESE.

The extent to which irrigation was early developed within the provinces of Novara and Mortara, led to the adoption therein of a unit of measure resembling that of Vercelli and Ivrea. It was called the *Oncia Novarese*, and consisted of the quantity of water issuing through an outlet, having an area of 12 square inches. The ancient statutes of Novara furnish, under date 30th July 1487, an illustration of the use of this measure in grants made by Ludovico Sforza, duke of Milan, from the canal Mora, the whole of which are expressed in "inches." At this period, however, the sole essential condition of the inch

of Novara was that it should be 12 square inches in area; no provisions for special height, or breadth, or pressure, were prescribed—and hence, of course, great differences in the value of outlets nominally the same. The *ruota* of Novara, consisting of 12 such inches as are above described, was also sometimes employed; but, as the outlets were equally indefinite for the larger as for the smaller measure, the results were equally unsatisfactory. Notwithstanding the introduction into the provinces of Milan and Pavia of a well-defined unit in the *Oncia Magistrale*, Novara and Mortara, though at the time under the same government, adhered to the use of the imperfect measure above noted; and to this day there are to be seen on the canals Mora, Busca, and Biraga, outlets with heads of water varying from 4 to 16 English inches, though they are nominally of equal value!

In the province of Mortara, there are examples of a peculiar measure which dates from the fourteenth century. In 1387, shortly after the opening of the canal of Sartirana, one of the lines on the left bank of the Sesia, various grants of water were made to different districts expressed in "inches," each consisting of the quantity of water passing through an opening, with the fixed height of 10 linear inches of Pavia, and a breadth of only 1 inch, or in English measure, 15.62 by 1.56 inches. It is curious to find measures of Pavia so far to the westward; but it probably arises from the fact that the hospital of this city was possessed of extensive property in the Lumellina, both in land and water.

The preceding details will suffice to show how many imperfections exist in the measurement system of Piedmont. It is impossible for the Government to rectify the errors of the past. There is but little hope of rooting out the evils which have grown up under the ancient regime;

but it is possible to introduce uniformity for the future; and perhaps, as the advantages of this become manifest to the community, it may even be practicable to remodel into convenient form that chaos which has been growing into greater and greater confusion for centuries past. As the first steps to this end, the legal establishment of a single uniform measure for the entire kingdom, and the prohibition of the use of any other unit whatever except that fixed by the civil code, are of much interest and importance.

IV. THE MODULO OF PIEDMONT.

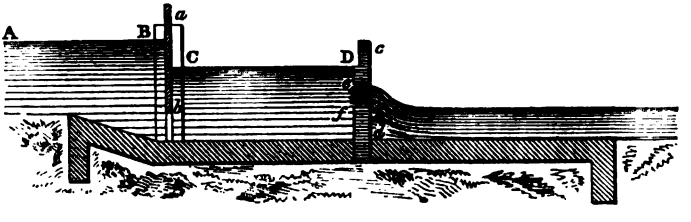
I have already given, in the course of the introductory remarks to this chapter, a translation of Article 643 of the Civil Code of the Sardinian States, which prescribes the essential conditions of the new module for the measurement of running water. Its dimensions in English measure are, height 7.874 inches, breadth 7.874 inches, with a head of pressure above the upper edge of the outlet equal to 7.874 inches. Its discharge, according to the official estimate, amounts to 2.04 cubic feet per second. When grants are made for more than one module, the only dimension which varies is the breadth of the outlet, the height and the pressure remaining in all cases invariable. Hence, for two modules, the breadth would be 15.748 inches, for three 23.622 inches, and so on, while the height and pressure would continue to be 7.874 inches respectively. The essential conditions of the module as defined in the code are, that the water should issue from the outlet by simple pressure; that this pressure should be maintained *practically* constant; that the outlet should be made in a thin plate; that the water, on issuing from the outlet, should have a free fall—unimpeded, that is, by

any back water; that the outlet should be square, with two of its sides vertical; and that the water of the supplying canal should rest with its surface free against the thin wall or stone plate in which the outlet is formed.

To give practical effect to these conditions has exercised, and continues to exercise, largely the ingenuity of the Piedmontese engineers; but, so far as I saw, modern skill has not yet surpassed the old arrangements of Soldati; and why these should not be adopted, instead of the very apocryphal improvements upon them which came under my observation, I cannot otherwise account for than by concluding that the unconcealed feelings of dislike between Piedmontese and Lombards prevent their acknowledging obligations to each other even in matters of this kind. I shall give examples hereafter of some of the forms of apparatus devised by the engineers of Piedmont for securing the uniform discharge of fixed quantities of water; but, meanwhile, I may select a single illustration of the system, so as to afford a general idea of how it is worked out in practice.

The following diagram represents the general arrangements for the issue of a certain number of "inches," or modules, as may be, and will sufficiently illustrate the object I have at present in view.

SECTIONAL DIAGRAM OF A PIEDMONTESE OUTLET.



A B, representing the supplying canal, the first part of the measuring apparatus is the sluice, locally termed the

paratoja, which consists of masonry side-walls, and a gate of wood, working vertically. The dimensions of this primary outlet are not rigidly fixed, its object being merely to admit a larger or smaller supply into the chamber C D. The sluice is established in the bank of the canal at such point as may be most favourable for the proprietor's object, or as may be fixed upon by the canal authorities. Its sill is sometimes on the same level as the canal-bed, sometimes above it, and very frequently, as represented in the diagram, there is a fall in front of the outlet so as to draw the water towards it. For a length of from 40 to 50 feet from the sluice, the bed of the channel is made perfectly horizontal, paved with masonry or cut stone—the upper surface of which is on the same level as the sill of the sluice. At a distance from the outlet, ranging from 16 to 32 feet, is fixed the partition or slab of stone *c d*, in which the regulating or measuring outlet *e f* is cut, of which the height is fixed at 6.72, while the breadth varies according to the number of *inches*, each *inch* being represented by 5.04 inches. The lower edge of the measuring outlet is ordinarily placed at 9.825 inches above the level of the flooring of the chamber C D. A small return, cut in the inner face of the slab at a height of 3.36 inches above the upper edge of the outlet, indicates the constant level of the water necessary to insure the established pressure. This height is maintained by the raising or lowering, as may be requisite, of the sluice at the entrance of the chamber.

On examining the different forms in use on the canals of Piedmont, I found excessive variety in the length and the breadth of the chamber formed by the sluice and the measuring outlet. Some had this part of the apparatus about 15 feet long, others 25, and some as much as 35 feet. The interior walls of the chambers, too, assumed all

sorts of forms, being sometimes circular, sometimes oval or pear-shaped, and occasionally so twisted as to defy description. The object of this variety of form is to destroy the velocity of the water within the chamber, so that the essential condition of issuing from the measuring outlet under simple pressure may, as far as possible, be fulfilled. I must frankly confess that, in nearly every instance which came under my personal notice, this desirable result was very imperfectly obtained. In fact, with such slopes, and consequently such velocities as the canals of Piedmont have, the elimination of the latter is beyond the power of such measures as are at present employed. There are, farther, no fixed rules for the dimensions of the sluice, with reference to those of the regulating outlet; and in a great many cases, even the fixed height which the latter ought to have is neglected; and the pressure, too, is not always observed, being sometimes double what it ought to be.

The general conclusion warranted by our examination of the measurement system of Piedmont, is, that while its past condition is useful only as showing us a great deal to avoid (a very desirable kind of information), its present state supplies us with something to copy in the distinct and legal establishment of a single well-defined unit of measure for the whole kingdom. Though the framers of the code did not consider themselves justified in establishing by law any special form of measuring apparatus, the Government is too sensible, I believe, of the importance of this point not to direct its attention to it, and, by introducing and enforcing on the canals under its direct control the best form which the present state of hydraulic knowledge suggests, to furnish a worthy example to the other canal proprietors of the kingdom, and so to bring the law and the practice into harmonious relation.

It may perhaps be useful, before closing this section, to give the formula used by the Piedmontese Commission on Weights and Measures, for calculating the value of the various measures of water employed throughout the country. It is as follows :—

$$Q = \frac{2}{3} u l \left\{ (a+b)^{\frac{3}{2}} - b^{\frac{3}{2}} \right\} \sqrt{2g}$$

where

Q represents the volume sought.
l The breadth of the outlet.
a The height of the same.
b The head of water giving the pressure, locally termed the *battente*.
g The force of gravity.
u The coefficient due to the contraction of the vein.

For the last-noted quantity, which of course varies with the dimensions of the outlet and the other conditions of the problem, the best determinations are given in the experiments of Poncelet and Lesbros, which include a great variety of cases, and among them some precisely analogous to the *modulo* and the *oncia* of Piedmont. The coefficient of contraction, with an opening of the same dimensions, and under the same pressure as the modulo, is 0.600 by actual experiment. For the oncia, however, it is necessary to obtain the coefficient by approximation, none of the experiments having been made with outlets exactly corresponding to it. Taking, however, the nearest dimensions, it appears that for every centimetre (0.393 inches), by which the height of the orifice under a pressure equal to that required for the oncia of Caluso, or between 8 and 9 centimetres (3.14 and 3.537 inches), was diminished, the value of u increased by 0.0015. To make this clearer, the experiments of Lesbros give for an orifice with a height of 20 centimetres (7.86 inches), and under the pressure due to the *oncia*, $u = 0.599$, and for an

orifice with a height of 10 centimetres, $u = 0.614$. Hence the difference in the value of u due the difference of height is 0.015 for ten decimetres, or as above, 0.0015 for each centimetre.

The calculations made by the Commission are given, of course, either in French or Sardinian measures, and the cumbrous ratios between these and our English measures entail considerable labour in attaining the results. The formula being, however, general, there is no difficulty in employing it; and if we had experiments on outlets, suited in dimensions, and other conditions, to the wants of our irrigation system in India, much practical benefit would be the consequence. Considering the great pecuniary and social interests concerned in this question, I may remark that it would be, in every respect, worthy of the Government of India to cause such experiments to be executed in connection with the canals under its charge, as they must form the very foundation-stones of a sound and substantial system of distribution and measurement.

The following Tables give the absolute and relative values of the water-measures of Piedmont, as determined by the Government Commission, which I have reduced to their equivalents in cubic feet per second, allowing 28.3 litres to a cubic foot.

I.—Table showing the Absolute Volumes of the Measures of Water for Irrigation in Piedmont.

Denomination of Measure.	Volume in litres per second.	Volume in cubic feet per second.
Modulo of the Civil Code, . . .	57.938	2.047
Oncia of Caluso, ...	24.053	0.849
Do. of F. D. Michelotti, . . .	27.928	0.986
Do. of Ignazio Michelotti, . . .	28.861	1.0198
Do. of Novara, ...	36.117	1.276

II.—TABLE SHOWING the RELATIVE VALUES of the WATER-MEASURES of PIEDMONT.

	Modules.	"Inches" of Caluso.	"Inches" of F. D. Michelotti.	"Inches" of Ignazio Michelotti.	"Inches" of Novara.
Modulo, ...	1.0000	2.4087	2.0745	2.0074	1.6042
Oncia of Caluso, ...	0.4151	1.0000	0.8612	0.8334	0.6659
Do. of F. D. Michelotti, .	0.4820	1.1611	1.0000	0.9676	0.7732
Do. of Ignazio Michelotti,	0.4981	1.1999	1.0334	1.0000	0.7991
Do. of Novara, . .	0.6234	1.5015	1.2932	1.2514	1.0000

SECTION II.

SYSTEM OF MEASUREMENT IN LOMBARDY.

As preliminary to a description of the measurement system of the Milanese, the most complete in Northern Italy, I will give some details, collected from various sources, regarding the measures of the other provinces of Lombardy. For the information given in this section I am indebted to the works of Tadini, De Regi, Brunacci, Bruschetti, and others, and to the courteous assistance of friends in the different localities, who spared no pains in giving me every assistance in their power.

I. ONCIA OR "INCH" OF THE PROVINCE OF LODI.

The combination of effort by which the great canal of the Muzza was originally executed, has left a curious

impress on the measure generally employed in the distribution of its waters. As the cities of Milan and Lodi united in bearing the expense of this work, we find the local measures of each employed in determining the *inch* of water, which is that quantity passing through an opening, having a height of 9, and a breadth of 1 of the linear inches of Lodi, while the pressure or *battente* is 2 of the linear inches of Milan. Is it possible that this most inconvenient arrangement can be another illustration of those feelings of mutual jealousy which existed between the two petty republics? Whatever was the origin of this use of two separate measures in the same apparatus, the results in practice must have been very unsatisfactory. The linear inch of Lodi is equal to 1.4934, and that of Milan to1.9257 English inches. Consequently, the dimensions of the water *inch* of Lodi are—height, 13.44; breadth, 1.49; and pressure, 3.85 English inches. From the first opening of the canal at the beginning of the thirteenth, to the end of the sixteenth century, it can scarcely be said that the oncia of Lodi had any determinable value, for no measures were taken to insure the constancy of pressure, or, in fact, any of the conditions on which accuracy of discharge depends. After the introduction, however, of the module of Soldati on the Naviglio Grande, the value of the *inch* of Lodi became more rigidly defined, and it is now considered by the Lombard engineers to be equal to 0.77 cubic feet per second.

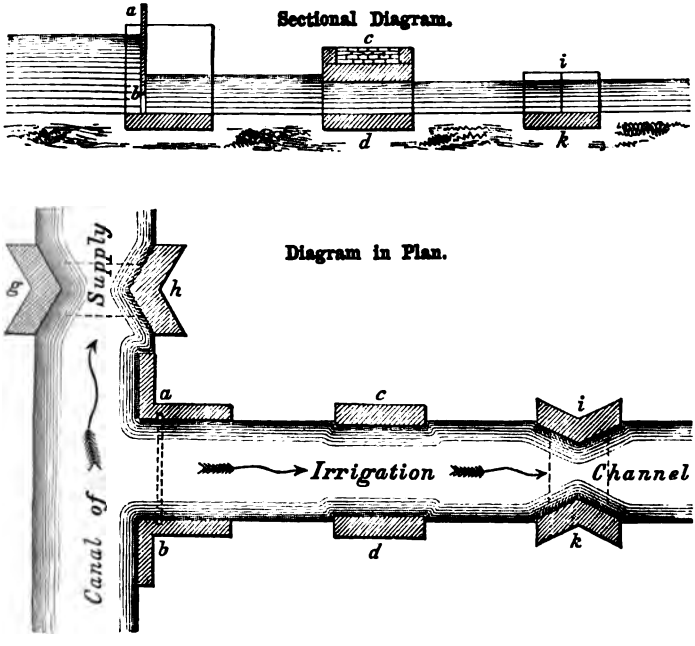
II. ONCIA OR "INCH" OF THE PROVINCES OF CREMONA AND CREMA.

I am indebted to Signor Elia Lombardini for the following details of the *inch* of Cremona. This measure is the quantity of water which, under simple pressure,

passes through an opening 15.838 English inches in height, and 1.572 in breadth, having a pressure or *battente* of 1.572 inches above the upper edge of the outlet. The volume is estimated at about 0.88 cubic feet per second, and for each additional *inch* the breadth of the outlet is increased by one local linear oncia, or 1.572 English inches, the height and pressure remaining constant. It is, however, fixed by very ancient regulations, that no single outlet shall have a greater volume than 24 water inches, which corresponds to a rectangle, having a height of 15.838, and a breadth of 37.728 English inches.

The measuring apparatus of Cremona is very needlessly complicated. The following diagram will make clear the arrangements adopted in it :—

MODULO OF CREMONA.



The head of the irrigation channel is established on the bank of the canal of supply at *a b*. It is provided with side-walls of masonry, extending in both directions for 12 or 15 feet, but its size is determined by no fixed rule. The entrance of water into the irrigation channel is regulated by a sluice-gate or *paratoja*. The bottom of this channel is carefully levelled, and maintained horizontal, sometimes by a pavement, most frequently without it, for a distance from the head varying from 60 to 80 feet. The proper measuring outlet is established at *c d*, being from 25 to 30 feet from the head. The outlet is not cut in a thin slab of stone as is usual, but is formed by a culvert or covered channel of variable length. By working the sluice at the head, a constant pressure of one Cremonese inch is maintained on the upper edge of the opening in *c d*, and the depth of water in the chamber between *a b* and *c d* ought, therefore, to be 11 Cremonese, or 17.292 English inches.

The double spurs in masonry, represented at *g h* and *i k*, are altogether peculiar to the Cremonese module. That at *g h* is intended to maintain invariable the level of the bottom of the canal of supply, near the outlet *a b*, and the sills of these two parts of the apparatus are at the same height. It is locally termed the *scagno*, literally the *bench* or *bank*, while the similar work at *i k* is called the *briglia*. This latter is placed at a distance of 250 feet from the head of the channel, having its sill depressed 1 Cremonese inch below that of the regulator at the head, and it ought, according to theory, to have a breadth equal to once and a half that of the outlet itself. In practice, however, this proportion is rarely observed, and is indeed sometimes literally inverted, the breadth of the *briglia* being actually less than that of the outlet from the canal of supply. Both the *scagno* and the *briglia* are therefore

merely profiles in stone, or sometimes wood, designed to maintain permanent the levels at once of the canal of supply and the irrigation channel, with reference to the sill of the head of the latter. The mouth of the covered channel, which serves as a measuring apparatus, is closed by a stone slab, in which an opening, corresponding to the number of *inches*, is cut; and on the edge of this opening, an iron scale, divided into breadths, representing such *inches*, is usually fixed. The length of the channel is about 15 feet, but in practice great variety in this and all other points is permitted.

It is evident from the arrangements of this apparatus, that it was devised originally at a time when the laws of discharge from orifices were but imperfectly apprehended. It is perfectly well known how difficult it is to estimate correctly the discharge from a single opening in a thin plate; when a covered channel of variable, but always considerable, length is annexed thereto, new elements of disturbance are introduced, the precise effect of which it is impossible to estimate. No fixed rule is observed for the proportions of the different parts of the apparatus; the variability of the breadths of the sills of the spurs in both channels causes them to be mischievous rather than beneficial, so that, on the whole, the Cremonese module does not command much confidence. It claims, however, to be the original form of the Lombardian measuring apparatus—to be the germ of the Milanese module. It is undeniable that the magistracy of Milan sanctioned, by a decree under date the 22d December 1551, the introduction of the Cremonese module into the irrigation system under their charge. The apparatus, however, was much simpler in detail than it subsequently became. The outlet was placed directly in the canal-bank; the discharge was through an opening of the dimensions prescribed for the

Cremonese *oncia*, cut in a thin slab of stone, and without any covered channel. The sill of the opening was placed at such a height above the bed of the supplying canal as to secure a constant height of 11 local inches of water over its inferior edge. But there is no trace of any regulating sluice or *paratoja* having been used till 1559, when the Podesta of Cremona, under orders from the magistrates of Milan, applied this means of controlling the supply, together with the covered channel and the double spurs of masonry—in fact, the normal Cremonese module—to the irrigating channels of the province. The inventor of the apparatus was an engineer of Cremona, by name Donenini, and the outlets of the canal Pallavicino were regulated by him after the manner described in 1561, and those of the Naviglio Civico of Cremona in 1585. Intermediately between these two periods, or about 1572, Soldati invented the *modulo magistrale;* but as it is in every respect so superior to that of Cremona, his claim to originality is scarcely affected by the brief priority due to the apparatus of Donenini. At this particular time, in truth, the evils of imperfect regulation so forced themselves into notice that thought was busy generally in devising means of removing them, and it is therefore most probable that Soldati and Donenini invented their respective plans independently of each other.

In the province of Crema the measuring apparatus is the same in its general arrangements as that of Cremona. But local measures being employed, there are some differences in the dimensions. The opening corresponding to the *water inch* of Crema has a height of 15.32, a breadth of 1.53 for each *inch*, and a pressure equal to 3.06 English inches. The same imperfections as already noticed in the modulo of Cremona produce like uncertainty in the volume of water discharged by that of Crema.

III. ONCIA, OR "WATER-INCH," OF THE PROVINCE OF BERGAMO.

This measure is a very peculiar one, being the solitary example in Northern Italy, so far as I know, of the employment of a circular instead of the usual rectilinear orifice. The *inch* of Bergamo is that quantity of water which passes through a circular opening, having a diameter of 1.73 English inches. It is, however, a measure of extreme uncertainty, since no determinate pressure is prescribed for it; and though for practical purposes tables have been prepared, showing the discharges with different heads of pressure, still it is generally admitted that it is one of the least satisfactory of the various local measures now employed, and there is therefore no special advantage in giving any minute details regarding it.

IV. WATER-MEASURE, OR "QUADRETTO," OF THE PROVINCE OF BRESCIA.

The Brescian *quadretto* is that quantity of water which passes through a square opening, having each side equal to one local *braccio*, or 18.66 English inches. In its original form some effort was made to maintain a constant pressure by prescribing that the centre of the *quadretto* should always be placed at mid-depth of the supplying canal; but in practice, even this somewhat obscure and imperfect condition is rarely attended to. When I visited Brescia, I was favoured with a paper on the water measure of the province, drawn up for me at the request of Signor Fillipo Ugoni, by Signor Corbolani, an engineer of that city in extensive employment. I give here a translation of this note, as it supplies some information of interest.

It will be seen that, so long as the superficial area of the *quadretto*, which is 144 local inches, is maintained, the form and linear dimensions of the outlet are by no means constant. The normal form is 24 inches by 6 ; but in practice, outlets are found of 12 by 12, of 4 by 36, and even of 3 by 48.

" As regards the manner in which canals or outlets for the distribution and measurement of running water are constructed in this province, I have," says Signor Corbolani, " to state as follows :—

" That by custom, dating from the sixteenth century, as was established by my late father from numerous ancient documents, water for irrigation or machinery is here distributed by the *quadretto*.

" A *quadretto* is that body of running water which passes through an opening, having a breadth of 24 *once*, or 2 *braccia* (equal to 37.32 English inches), and a height equal to 6 *once* (or 9.30 English inches). The following arrangements are made to secure regularity of distribution :—

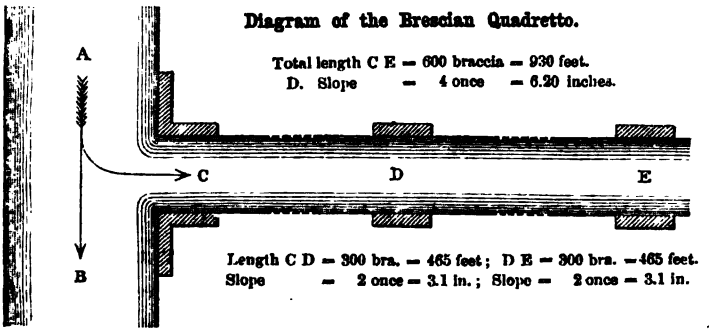


Diagram of the Brescian Quadretto.
A
Total length C E = 600 braccia = 930 feet.
D. Slope = 4 once = 6.20 inches.
C
D
E
B
Length C D = 300 bra. = 465 feet ; D E = 300 bra. = 465 feet.
Slope = 2 once = 3.1 in. ; Slope = 2 once = 3.1 in.

" In the bank of the principal canal, A B, from which the supply is to be obtained, an outlet of masonry (*bocca*) is constructed, having a breadth of 24 local inches, and a height determined at the discretion of the proprietor.

This head is furnished with a sluice-gate (*paratoja*) so constructed as to be raised or depressed with facility, to regulate the quantity of water admitted into the irrigating channel C D E.

" This channel is carried in a straight line from the outlet for a distance of not less than 930 feet, with a fall in this length of 6.20 inches.

" Midway in this channel, or at a distance of 465 feet from the head, is established the *modulo* or regulator D, having a length of 18.60 feet, an opening at its mouth of the dimensions corresponding to the number of *quadretti* it has to supply, but with no arch or covering, and so consisting simply of side-walls and flooring in masonry, the latter being 3.10 inches below the sill of the outlet at the head.

" At the distance of 930 feet, a solid bar of masonry (*briglia*) with side-walls is constructed in the bed of the channel with a length of 9.30 feet, and a breadth the same as that of the regulator at D. The sill of the *briglia* is 3.10 inches below that of the regulator at D, or 6.20 inches below the level of the flooring of the head.

" These arrangements made, the sluice is so regulated as that the height of water at D shall not exceed 9.30 inches, and the quantity of water then issuing is one *quadretto* of Brescia.

" When larger or smaller quantities are necessary, the breadth of the outlet is varied accordingly, but the height of water remains constant at the regulator D.

" Certain outlets in the province are square, having each side equal to 1.55 English feet ; but these are the oldest forms, and are not now approved, the dimensions I have just stated being those preferred in all new grants."

The defects of this system are apparent at a glance. The almost impossible provision of no pressure at the

regulator, which leads to extreme variations of volume, is essential—the water, instead of passing the regulating opening with no velocity, arrives at it with that due to a fall of between 2½ and 3 feet per mile; and as the linear dimensions of the regulator vary much in practice, it is evident that the value of a *quadretto* is really beyond accurate determination. There are other forms of apparatus in use, such as having two or three regulating outlets, but the fundamental errors noticed above affect the whole, without a single exception that I am aware of.

V. WATER MEASURE OR "QUADRETTO" OF THE PROVINCES OF VERONA AND MANTUA.

The peculiar position of these two provinces, as being irrigated from the same rivers, while for a long period they belonged to different powers, has led to an infinity of rules and regulations regarding the distribution of water within them. The system in force, however, is far less perfect than might have been anticipated from the circumstances of the case, and is, in fact, scarcely superior to the methods of adjoining provinces, on which much less interest has been bestowed.

The *quadretto* of Verona is that quantity of water which passes through an opening of one Veronese foot, or 18.27 English inches square, under a pressure of 3.04 inches above the upper edge of the outlet. The opening is made in a plate varying from 3 to 6 inches in thickness, and the discharge should take place under the influence of simple pressure without velocity. Strange to say, the height of the outlet—which, whatever be the number of *quadretti* issued, ought to remain fixed, while the breadth only varies—is changed constantly in practice, so that the determination of the real value of this measure

is about as impracticable a problem as Italian irrigation presents. I endeavoured in vain to procure precise information regarding it, as those best qualified in the country had no common agreement on the point.

Throughout the more easterly provinces of the Lombardo-Venetian Kingdom, there is no well-defined system of measurement of water. This is readily explicable, from the very limited extent to which irrigation is developed over their surfaces. On this subject, Brunacci remarks (*Memoria*, p. 54), "In the Venetian provinces there are no fixed methods for the distribution of water, nor is there any established unity of measure. In all grants of water made there, we find specified only the area of the outlet, and the use to which the water issuing from it is to be applied. No reference to the pressure or any other circumstance warrants us in inferring that the element of velocity was taken into consideration. Nor is this to be wondered at in localities where the nature of the soil, and the deficient supply of perennial streams, forbid the development of an agriculture requiring extensive and repeated irrigation."

SECTION III.

MEASUREMENT SYSTEM OF THE MILANESE.

As preparatory to the detailed description of the *modulo magistrale* of Milan, I may first state in outline the essential conditions which, according to the most approved Italian authorities, are to be fulfilled by a trustworthy apparatus for the measurement of water employed in irrigation. To claim rigid accuracy for any such ap-

paratus, in the present condition of hydraulic knowledge, is impossible; but where the object is the practical one of measuring the water issued within reasonable limits of error, satisfactory results may, I think, be obtained.

The general laws by which the motion of fluids is regulated are sufficiently familiar to make it unnecessary for me to dwell at any length upon them. The basis of all formulæ for discharge by orifices is the Torrecellian theorem, published first in 1643, which establishes the law that, "if no disturbing causes interfere, the velocity of a fluid, on issuing from an orifice in the side of a reservoir, is that which would be acquired by a heavy body in falling freely from a height equal to the distance between the surface of the fluid and the centre of the orifice." According to the first principles of accelerated motion, the velocity of a freely-falling body is proportioned to the time consumed in acquiring it, and the height to the square of this time. Hence we have the elementary expressions

$$v = \sqrt{2gh} \text{ and } h = \frac{v^2}{2g}$$

in which v represents the velocity of the fluid on issuing from the orifice, h the height corresponding to this velocity, and g the constant of gravity; whence it follows, from the relations thus established between the velocities and the heights corresponding to them, that if a series of orifices be opened, in the same vertical line, in the side of a reservoir, the curve which results from taking the heights as abscissæ, and the velocities due to these heights as ordinates, will have its abscissæ proportional to the square of its ordinates; or, in other words, the curve in question will be the parabola, the properties of which supply the means of calculating with simplicity the velocities corresponding to given heights, as has been done

by De Regi, in his "*Tavola Parabolica per le Bocche d'Irrigazione*," a work which I found of high authority among the engineers of Northern Italy in all hydraulic calculations.

The means thus existing for determining the velocity due to given heights of water, it might seem that, to obtain the discharge, it was only necessary to multiply the area of the section of the outlet by the velocity corresponding to the head of pressure, or *battente* over it. But, in truth, there is no branch of physics in which the theoretical correspond less with the observed results than in hydraulics, and the most approved formulæ, with every possible correction, are still far from rigidly accurate. There are numerous disturbing elements to be taken into account, some of which remain still but imperfectly determined. *First*, the coefficient, representing the force of gravity, varies with the latitude and the elevation of the locality; and it is necessary, to the accuracy of the discharge, that its exact numerical value should be known. *Second*, The discharge from an orifice is modified by the resistance of the air, and never in practice conforms to the theoretical condition of a vacuum. In cases of outlets for irrigation, the discharge almost invariably takes place in a fluid medium, and is modified by the resistance of the water. *Third*, There is scarcely a single condition of the supplying channel, as regards its form, its inclination, the material of which it is composed, and numerous other physical circumstances, which does not react on the volume discharged from a given outlet under a determinate pressure. And, *fourth*, The form of the outlet itself is of the last importance to the estimate of the volume of water it is capable of discharging under given circumstances. According as this form varies, the coefficient representing what is technically called "the contraction of the vein"

varies also, and to an extent which influences, in the first degree, the discharge from it. The determination of this coefficient has been the object of many series of experiments, the most complete being that of MM. Poncelet and Lesbros, published in 1832, under the title of "*Experiences Hydrauliques Metriques*," for an abstract of which I am indebted to the "*Idronamica*" of Colombani. According to these experiments, it appears that, for orifices of the dimensions, and with the pressures most common in irrigation, the mean coefficient of contraction is between 0.62 and 0.63. But even at best these results must be used with caution, as many circumstances will occur in actual practice to modify them. I do not know that any satisfactory experiments have yet been made on the discharges of outlets, partially or wholly immersed in water, as is constantly the case with the heads of channels of irrigation. Many new conditions arise in such cases to complicate the problem, and I confess I have little or no confidence in any of the existing means of solving it. The best result that can at present be obtained should, therefore, be regarded as simply an approximation to the truth, and nothing more.

The conditions essential to the practical working of a good system of measurement are thus stated by Brunacci ("*Memoria*," p. 71).

"In order that orifices in two separate reservoirs, maintained constantly full, should discharge equal quantities of water in equal times, it is necessary—

"1. That the two orifices should have exactly the same area, the same form, and especially the same perimeter.

"2. That they should be placed at the same depth beneath the surface of the water.

"3. That the plates or partitions in which the orifices are cut should have the same thickness.

"4. That the water in both reservoirs should be equally calm or equally disturbed on its surface, or throughout its mass, in the vicinity of the orifices.

"5. That the directions in which the water passes through both orifices should be the same.

"6. That the water, if not stagnant, should arrive at the two orifices with the same velocity.

"7. That the discharge of the water from the orifices should be equally free or equally checked—that is, if canals are attached to the outlets, they should have equal sections, slopes, or other conditions.

"8. That if the discharge is made in water, the reaction should be the same in both cases."

These conditions were originally indicated about the middle of the sixteenth century, and they include nearly everything that could influence the discharge. It will be seen, however, that some of them are purely theoretical, and their attainment in practice would not be possible. Looking simply, therefore, to the demands of an ordinary irrigation system, a module which effected perfectly the following results would leave little to desire; and in proportion as existing forms do effect them, they may be ranked higher or lower in the scale of practical value. The results sought are—

1. That, wherever placed, outlets nominally of equal discharge should always furnish, in given times, exactly the same quantities of water.

2. It is an essential result that the discharges should be equal, however the level of the canal of supply may vary.

3. The measuring apparatus should be so constructed as to render it impossible for its proprietors, or any other person whatsoever, to alter in any way its discharge, without leaving traces of such attempts easy to be recognised.

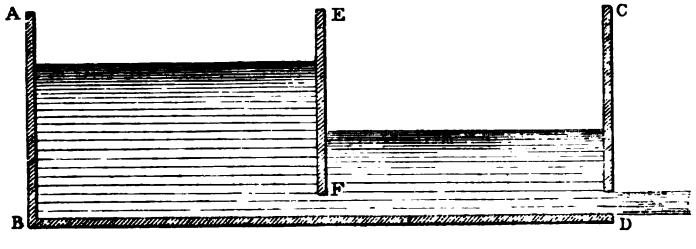
4. That the manner of working the apparatus should be so simple as to require no more than the most ordinary intelligence on the part of the officials intrusted with its regulation, so as to avoid all risk of its being injured either by their awkwardness or ignorance.

5. That no calculation should be necessary in regulating the discharges; but when alterations of the quantity of water were necessary, they could be made at once by the mere adjustment of the measuring apparatus.

6. The apparatus should occupy but a limited space, so as to admit of its being applied in all localities.

7. The normal discharge, or unity of measure, being once determined, the apparatus ought to be so constructed as to insure constancy of volume from large and small outlets.

When these seven conditions are exactly fulfilled, the problem of a measure of water, perfectly applicable to the wants of the most extensively developed system of irrigation, will be solved. I may now proceed to show in how far the *modulo magistrale* of Milan has effected this; and, first, as regards the elementary principles on which its construction is founded.



Let A B C D be a vessel supplied with water, having an outlet at D, and divided vertically across its breadth by a partition or diaphragm E F, which can be placed at variable heights above the bottom of the reservoir. On

investigating the phenomena of discharge under these circumstances, the early Italian experimentalists found—

1. That there was established between the two compartments of the reservoir a constant difference of level, and that this difference was proportionally greater according as the opening of the diaphragm was less in comparison with that of the outlet. In other words, the opening at D remaining constant, and that at F being variable, the difference between the levels of the water, in the compartments A E F B and F E D C, was found to be proportional to the difference between the areas of the outlets at D and F. As F became less in proportion to D, the difference of level increased, as might have been expected.

2. That if, instead of maintaining the level of water in the reservoir constant, it was subjected to elevations or depressions, the variations corresponding to these were found to continue proportional to the heights originally established in the two compartments respectively, for a given condition of the orifices of discharge and communication; in other words, if, when the level in the reservoir was maintained constant, the heights of water in the two compartments were to each other as 3 to 1 ; then a depression of the level of the first compartment, to the extent of, say, 3 feet, would produce in the second a depression of 1 foot ; 18 inches in the first, 6 inches in the second, and so on.

3. That this principle was not affected by the employment of two or more partitions ; that is to say, the same relative proportion was maintained between the variations of level and the original heights of water in the first and last compartments, whatever addition was made to the number of the intermediate diaphragms.

The application in practice of the principle here stated is sufficiently clear and simple. Suppose the first com-

partment, A B E F, to be a canal or reservoir, E F the sluice-gate at the head of an irrigating channel, and D the regulating or measuring outlet—it is clear that, by raising or depressing E F according as the variations in the level of the main canal render necessary, a fixed and constant height of water may be maintained over D, and that condition, which in all irrigating countries has been recognised as the most important to a good module, may thus be practically secured. I need scarcely remark, that as the physical circumstances of canals of irrigation make changes of level very frequent, a certain amount of fluctuation in the volumes, discharged by every module, must necessarily be tolerated. What this amount may be is of course dependent on local considerations and convenience, but the moment it is passed, an apparatus, constructed on the principles above noticed, furnishes the means of at once re-establishing it in its normal condition. But it is to be observed further, that, independently of the power thus supplied to establish, when it is considered necessary, an exact pressure on the measuring outlet, the sluice or *paratoja* produces an important effect by its mere presence. For, on the principle expressed in the second of the results of the Italian experimentalists before given, the variations of level in the main canal produce on the water within the module the minima of alteration, and the greater the difference of height between the water outside and inside the sluice, the more marked is the diminution of the effect of changes of level in the former. As a numerical illustration of this point, it has been found that, in the Milanese module, when the difference of height between the water on each side of the sluice amounted to 6.96 feet, a depression of level outside, or in the canal, to the extent of $4\frac{1}{2}$ inches, led to a variation in the interior of the module of a little less

than a single inch. The pressure on which the discharge of the module so intimately depends was, therefore, affected to the extent of about one-fourth of the variation in the supplying canal; and the same proportion would continue if the sluice should remain in a fixed position. Its passive influence, so to speak, is accordingly of material use in practice.

Although the introduction of the regulating, or, as it is sometimes termed, the hydrometric sluice, is the most important step in the improvement of the measuring apparatus of Italy, there are other circumstances which are also very essential. These are, the distance of the measuring outlet from the head, the form of the chamber included between those points, the form and dimensions of the chamber below the measuring outlet, the proper dimensions of the measuring outlets themselves. These latter conditions vary exceedingly in different cases; and in looking to the approved modules of Northern Italy two distinct points are to be noted. 1st, That each exhibits in the *paratoja*, or hydrometric sluice, a fixed and fundamental portion of the apparatus destined to insure constancy of pressure on the measuring orifice; and, 2d, That they exhibit various arrangements, differing in each, designed to regulate the condition and movement of the water in the module, both as affected by the supplying canal and the channel of distribution. These general remarks may prepare the way for a clear conception of the module of the Milanese, which I now proceed to describe.

The historical sketches of the great canals of the Milanese, given in Part II., have rendered unnecessary any detailed account of the circumstances under which the *modulo magistrale* was introduced. The crying evils arising from the fraudulent appropriations of the

waters of the Naviglio Grande were the moving causes to the establishment of this measure. From the commencement of the thirteenth to that of the sixteenth centuries, grants of water in the Milanese were made in the *rodigine*, the synonym, as formerly mentioned, of the Piedmontese *ruota*, the French *œil de meule*, or the *moulan d' eau*, and literally, in English, "the wheel." The *rodigine* was the quantity of water passing through an opening, having an area of 72 local square inches, and of which the sill was placed 8 inches above the bottom of the canal. It was subdivided into 6 water-inches, but as no conditions regarding pressure were fixed for it, its absolute value is unknown. The *oncia*, or water-inch, was also employed in regulating grants of water; it was the quantity of water passing through an opening of 12 local square inches, of which the sill was placed at 8 inches above the canal-bed in the Naviglio Grande, and 4 inches for the river Olona. The water-inch, however, was a measure quite as undetermined and unsatisfactory as the *rodigine*.

It is not until the beginning of the sixteenth century that we find any accuracy introduced into the water-measures of the Milanese. In 1503 the following instructions were issued:—1. That all outlets should be made in slabs of granite or marble, with a fixed height of 4 local inches. 2. That they should be established in the banks of the canals, without accompanying dams, spurs, or any other like works. 3. That the outlet, properly so called, should have attached to it a chamber in masonry of the length of 9 *braccia* (17¾ feet), of which the lateral walls parallel to each other should form on each side a return of 3 inches (5.895 English inches) in excess of the breadth of the outlet. 4. Finally, that the sills of the outlets should be established at heights fixed for each canal according to the depth of water in it.

The first rude outline of the *modulo magistrale* is to be traced in these regulations. An attempt is made to regulate the discharge from the outlets by the introduction of a masonry chamber; but as yet the means of establishing a fixed pressure had not been devised. It was between 1559 and 1561 that the hydrometric sluice was first employed, and then in association with the module of Cremona, which, as we have formerly seen, combined with it, by a sort of perverse ingenuity, as large a number of imperfections as such an apparatus could display. Ten years later, or in 1572, Soldati submitted to the magistracy of Milan the *modulo* he had invented; and it is curious to note that it was constructed on purely empirical data, for at that period it may be said that the scientific principles of hydraulics were scarcely known. In the history of the Naviglio Grande I have given the conditions of the problem, as submitted by the magistrates to the engineers of Milan, and of these I may repeat here the three which may be considered fundamental.

1. To indicate the best unit for the measurement of water employed in irrigation, and such a method of distributing it as should be injurious neither to the public treasury, to navigation, nor to the consumers.

2. To discover an apparatus which should be competent to discharge in a given time, by outlets of fixed dimensions, a constant volume of water, whatever may be the variations in the level of the supplying canal: or that this volume, once fixed under a known pressure, should be rendered perfectly independent of the variations which might take place either in the level of the water, or in the form or direction of the canal.

3. To construct the apparatus so that it would oppose all possible obstacles to that system of fraud or alteration by which a greater quantity of water had been obtained

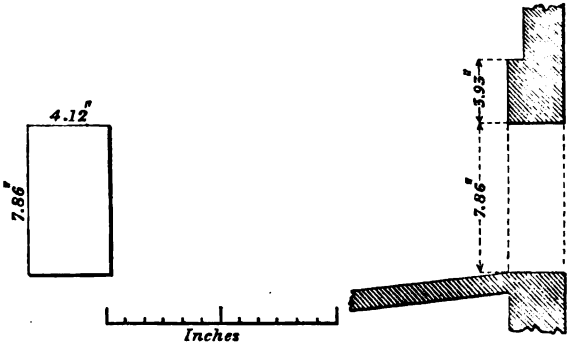
than was originally granted, and which had hitherto prevailed throughout the country.

These instructions were fulfilled by Soldati in the following way :—

The unit of measure fixed upon was called the *oncia magistrale*, and is that quantity of water which flows freely, or under the sole influence of pressure, through a rectangular opening, having a uniform height of 4 local inches (7.86 English inches), a breadth of 3 local inches (4.12 English inches), and a constant pressure of 2 local inches (3.93 English inches), above the upper edge of the outlet.

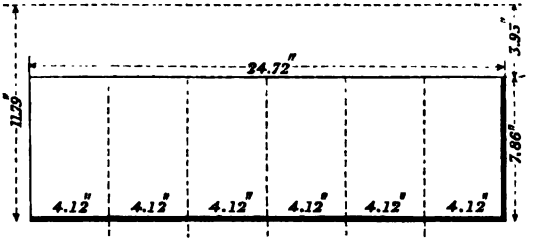
The diagram below exhibits to the eye the dimensions of this unit of measure.

ONCIA MAGISTRALE OF MILAN IN ENGLISH MEASURES.



It is essential that the above dimensions should be rigorously observed, and especially that the constant pressure of 3.93 inches over the outlet should be maintained. When one outlet is designed for the discharge of several water-inches, the breadth only varies in the proportion of 3 local linear inches (4.12 English inches) for each additional water-inch, the height and the pressure remaining constant, as thus—

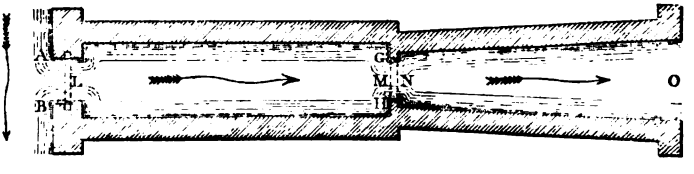
OUTLET FOR 6 WATER-INCHES.

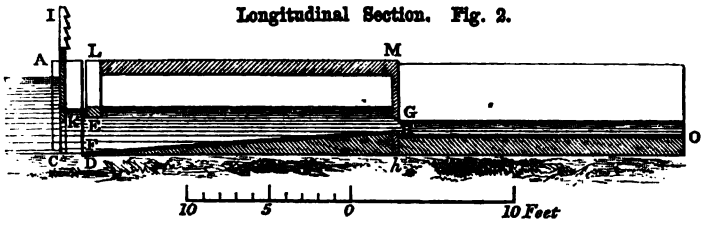


The outlets are cut with care in a single slab of stone, which varies in different localities, being in some granite, in some mica slate, and in some marble. To preserve them from being tampered with, an iron rim is fixed upon them of the exact dimensions corresponding to the discharge. They ought invariably to be cut in a simple plate, with no arrangement of any kind to increase the volume beyond that due to pressure alone. The thickness of the slab varies somewhat with the dimensions of the outlet, but in a rigidly exact module this dimension should be fixed in common with all the others. These are the conditions applicable to the measuring outlets. To illustrate the other arrangements of the *modulo*, I give below a plan and section of it in its complete form.

MODULO MAGISTRALE OF MILAN.

Plan. Fig. 1.





Longitudinal Section. Fig. 2.

The head A B, Fig. 1, is placed on the bank of the canal of supply with the sill C D, Fig. 2, on the same level as the bottom of this canal. It is formed of two side-walls or cheeks, of good masonry, in brick or stone, with a flooring generally of the latter material. To prevent erosive action, the bed of the canal, for such distance as the force of the current may render necessary, is paved with slabs of stone or boulders, both above and below the head. The outlet of the head is usually made of the same breadth as that of the measuring orifice G H, Fig. 2; while its height is regulated by that of the head itself. The sluice-gate or *paratoja*, I K, Fig. 2, works in grooves, and is fitted with a rack and lever, by which it can be readily raised or depressed at pleasure. As the surface level of the canals of the Milanese varies comparatively little, the upright of the sluice has a small catch in iron or wood attached to it, by which it is kept at a fixed height corresponding to the requisite pressure on the orifice G H, Fig. 2. This little catch is locally termed the *gattello;* and as it is provided with a lock and key, the latter of which is intrusted to the guardian of the canal, the proprietor of the water-course is supposed to be restricted to his legitimate supply; and probably is so, within reasonable limits, provided always that the guardian is incorruptible.

In rear of the sluice-gate at the head is placed the

first chamber, L M, Figs. 1 and 2, called in the language of irrigation, the *tromba coperta*, or covered chamber. It has, in the established form of the *modulo*, a fixed length of 10 *braccia*, equal to very nearly 20 English feet, and a breadth variable according to the size of the head-sluice, which it exceeds by the fixed quantity of 5 local inches on each side, or 10 on the entire breadth, being nearly 1.64 English feet. The bottom of the covered chamber, D H, Fig. 2, is formed with a slope to the rear, or as a ramp : the height of this slope, H *h*, is equal to 8 local inches, or $15\frac{3}{4}$ English inches very nearly; and its object is to diminish the velocity with which the water reaches the measuring outlet G H. Farther to assist in effecting this object, the perfect *modulo* is provided with a horizontal top of stone slabs, or planks, called the *cielo morto*, the under surface of which is at precisely the same height as the water ought to have over the outlet G H, so as to secure the fixed discharge ; that is, 3.93 English inches above the upper edge of G H. The great purpose of the apparatus being to secure the discharge taking place under simple pressure, the *cielo morto*, which may be roughly rendered *the deadening cover*, is found to reduce the irregular motion of the water in passing from the sluice A B to the measuring outlet G H.

To admit of ready inspection of the state of the water within the covered chamber, the following arrangements are made :—The entrance to the chamber is covered by a stone slab of convenient thickness, shown in section at E, Fig. 2, the lower surface of which is precisely on the same level as the upper edge of the outlet G H. The height of the ramp H *h* being 15.72, and that of the outlet G H being 7.86, the surface of the slab at E should be just 23.58 English inches above the sill of the head C D. An open groove, L D, is made in the masonry, large enough to

admit a graduated rod or measure; and when the water stands at a height of (23.58 + 3.93) 27.51 inches above the sill at D, it is known that the proper head of pressure exists at G H. As it is found to be greater or less, the sluice is raised or depressed, so as to adjust the pressure to the fixed standard.

The slab of stone in which the measuring outlet is cut being fixed at G H, Figs. 1 and 2, immediately in rear of it there is placed the *tromba scoperta*, or open chamber. Its breadth at N, Fig. 1, is two local inches, or 3.93 English inches greater on each side than that of the measuring outlet; or in all, 7.86 inches. Its total length, N O, is very nearly 17¾ English feet. Its side-walls, which are perpendicular like those of the covered chamber, have a splay outwards, so that the breadth at O is 11.79 inches greater than at N, or 15.72 inches in excess of that of the regulating outlet G H, being the same as that of the covered chamber throughout. To insure the free run of the water from G H, the flooring of the open chamber has a drop or fall of 1.96 inches at H, and an equal quantity distributed uniformly between H and O, Fig. 2. There is, therefore, a total fall from the under edge or lip of the measuring outlet to the end of the open chamber of 3.93 inches; or—as the length is 17.72 feet—very nearly 1 inch in 54. When the water reaches O, it enters the channel of distribution, and becomes the property either temporarily or permanently of the parties to whom the grant of it has been made. Arrangements at O vary. Sometimes there is a fall from the end of the *modulo* to the bed of the channel; but generally the two are on the same level, the latter being carried forward at the usual slope for such works.

From the preceding details, it therefore appears that the *modulo magistrale*, in its normal form, has a length of

nearly 37⅜ English feet, and a breadth variable according to the quantity of water it is designed to measure. If a single "water-inch," for example, be the volume, the breadth of the covered chamber would be 25.54 inches, and that of the open chamber 13.75 at its upper, and 25.54 at its lower extremity. The flooring of the former rises 15.72 to the rear, while that of the latter falls 3.93 in the same direction.

It is essential to the effective operation of the regulating sluice in the *modulo magistrale*, that there should be a difference of level between the water in the canal and in the apparatus of at least 7.86 inches; and as the height of water in the latter must be 27.51 inches, the depth of water in the canal of supply must necessarily be not less than the sum of these numbers, or 35.37, being very nearly 3 feet. In this case the relative heights of different parts of the works are given below, the bottom of the canal of supply being the zero line.

	English inches.
Bottom of the canal,	0.00
Level of the water in the canal,	35.37
Level of the water in the interior of the *modulo* giving the constant pressure,	27.51
Level of under surface of the stone slab at the mouth of the covered chamber, and of the upper edge of the measuring outlet,	23.58
Level of lower edge of measuring apparatus at the end of the ramp of the flooring of the covered chamber,	15.72
Level of the flooring at the head of the open chamber,	13.75
Level of the flooring at the termination of the open chamber,	11.79

In analysing this *modulo*, two essential objects become apparent, to the fulfilment of which the various details just given are directed. 1st, To maintain on the measuring outlet a constant pressure; and, 2d, To make this pressure, as much as possible, the sole force influencing the discharge. To the first object are directed the different mechanical arrangements at the head, the *paratoja* duly

provided with the *gatello*, and, to a certain extent, the *cielo morto*. To the second belong the interior arrangements of the covered chamber, with its sloped flooring and fixed top; while the free passage of the water is secured by the open chamber, with its small fall at the head and continued inclination of the bottom.

I purpose giving, in the description of the Plates, the details of several examples of canals of distribution regulated by the *modulo magistrale*, which will illustrate the extent to which, in practice, the normal form has been departed from. I examined personally a great number of these works, and I can scarcely say I found any which conformed rigorously to the prescribed form. The lengths of the chambers varied continually, and apparently according to the fancy of the engineers by whom they had been constructed. One-half the normal lengths was a not unusual proportion; but the breadths, with reference to those of the measuring outlets, were usually observed more carefully. In a great number, the *deadening cover* was wholly dispensed with; in many more, the backward slope of the flooring of the covered chamber did not exist, though the lower edge of the measuring outlet was maintained at the prescribed height of 15.72 inches above the level of the sill of the head of the canal. All these variations are unquestionably imperfections, though they cannot be said to destroy the utility of the apparatus; and it is matter of regret that they should have been permitted to grow up as they have done. Discretion in changing the details of a measuring apparatus should be vested in the Government only, which can from time to time sanction such alterations as seem likely to add to the efficiency of the work; but for private parties to be allowed to follow their own caprices, is ruinous to the existence of any well-defined and generally-recognised

system of measurement. Its results become uncertain; its unit ceases to be a fixed quantity; and things relapse into that state which favours fraud by defying easy verification.

An apparatus so extensively employed, and linked in its action with interests so important as the *modulo magistrale*, has necessarily engaged much attention, and caused no small amount of discussion among mathematicians and engineers. Though admitted on all hands to be the best form yet devised for use in irrigation, these discussions have drawn attention to some sources of error which affect its results very materially.

In seeking to ascertain the real value of an *oncia magistrale* of water, as measured by the *modulo magistrale*, I have been struck by the variety of results different authors give. I am indebted to the *Idrodinamica* of Colombani for some of the following values, to the tables of the Piedmontese government for others, and I give them to show practically that the *modulo* of Milan cannot yet be said to have fulfilled its object perfectly.

According to the calculations of De Regi, in his *Tavola Parabolica*, p. 67, 68, the value of an *oncia magistrale* is 2.43 cubic metres per minute, or, in English measure, very nearly 1.42 cubic feet per second.

Bruschetti gives a long detail of experiments made in 1744 by the engineer Merlo on the Muzza Canal (*Stor. Irrig.*, p. 230, *et seq.*) to determine the value of the Milanese *oncia*, the mean result of all of which is to make it equal to 1.57 cubic feet per second.

Signor Mazzeri, who was kind enough to communicate many details of this kind to me in person, estimates the value of the *oncia* at only 1.21 cubic feet per second.

Brunacci estimates it at 1.46 cubic feet per second, while the Department of Public Works in Lombardy con-

sider it to be equal to 1.64 cubic feet per second. The highest estimate, so far as my examination has gone, is that last mentioned, or 1.64 cubic feet per second, while the lowest is 1.21 cubic feet per second, as given by Signor Mazzeri, and generally adopted by the engineers of Lombardy. The difference between these extreme estimates is very considerable, being between one-third and one-fourth of the total quantity discharged.

The origin of these differences is due to a cause which affects the whole of the modules of Northern Italy. The experience on which the estimates of the engineers is founded has been generally derived from dealing with small quantities of water not exceeding one or two inches. The estimate made by the Government is founded on the experience of the results on the great canals, where the outlets are almost uniformly of large dimensions. Now, it is certain that, all other circumstances being alike, the quantities of water discharged from large outlets are proportionally greater than those discharged from small ones. Hence the *oncia magistrale* as determined by experiments with the former, has a decidedly higher value than when determined from the latter. The cause of this is clear. To give a discharge, say of six water-inches, the breadth of the outlet is made six times that for one inch, the height and the pressure remaining in both cases the same. The proportion between the sectional areas and the perimeters of the outlets becomes, however, materially altered, and the influence of the perimeter, in effecting the contraction of the vein, diminishes gradually as the size of the outlet increases, and, in a similar proportion, the discharge becomes greater. In elucidation of this remark I may state that, in an outlet for one *oncia magistrale*, the ratio of the section to the perimeter is as 1 to 23.33; of 2, as 1 to 16.66; of 4, as 1 to 13.33; of 8, as 1 to

11.66; of 10, as 1 to 11.33, or about half what it is for one *oncia;* of 20, as 1 to 10.66, and so on; and there are real differences of discharge due to the variable ratios now given. Very serious pecuniary loss may consequently be the result either to the proprietors or the consumers of the water. The recognition of the differences between the discharges of large and small outlets was very early made in Lombardy. In the module of Cremona, invented in 1561, no single outlet was allowed to be more than 15.72 inches high, and 38.12 inches broad—equal to about 12 or 13 *once magistrale.* In the Milanese, single outlets have been restricted for nearly three centuries and a half to discharges of from 9 to 12 *once.* In Piedmont they have been more careful, and have there limited single outlets to 6 *once,* which, by general consent, seems to be the most approved size for diminishing to the utmost the error due to the inequality of discharges from large and small openings. For practical purposes, therefore, and taking the mean of the various estimates of the value of the *oncia magistrale* just adverted to, I think it may safely be considered as equal to very nearly $1\frac{1}{2}$ cubic feet per second. The following short extract from Brunacci (*Mem. sulla Dispensa delle Acque,* p. 140), showing the conclusions at which he had arrived after a minute discussion of the various methods in use for measuring water throughout Italy, will close appropriately this section :—

"On the grounds previously detailed, we are of opinion,

"1st, That of all the methods in use throughout Italy for the measurement of water, the method of the Milanese is the most convenient.

"2d, That, in addition to reducing the local to metrical measures, the other precautions to be adopted in perfecting its operation are as follow :—

"*First*, To establish by careful observation, with an hydrometer, the variations of the height of water in the canal of supply, and to mark on a scale the respective positions of the sluice-gate required to neutralise such variations in the interior of the *modulo*.

"*Second*, To enjoin the guardians to be most careful in fixing the gate at the special point prescribed for each variation, so that the *battente* or pressure may be constant.

"*Third*, To make no outlet greater than eight times the unit of measure; and when a discharge greater than this is necessary, to obtain it by the construction of two or more outlets in the same edifice, with the precautions formerly described, so that each outlet shall be quite independent of the other, and have all the essential conditions of constancy, just as though it stood by itself.

"*Fourth*, Finally, to substitute for each *oncia* of the *braccio* of Milan, in the dimensions of the apparatus, one-half a decimetre (or 1.96 English inches)."

The following table shows approximately the volumes of the principal water-measures referred to in the preceding sections, and may be useful for reference :—

TABLE showing the VOLUMES in CUBIC FEET per second of the following WATER-MEASURES of LOMBARDY.

	Volume in cubic feet per second.	Ratio of each to the oncia Milanese as unity.
1. Oncia Milanese, ...	1.50	1.
2. Oncia Lodigiana, ...	0.77	0.513
3. Oncia Cremonese, ...	0.7175	0.478
4. Quadretto Veronese, ...	5.0890	3.392
5. Quadretto Mantovana, ...	11.0005	7.333

SECTION IV.

ON THE INTRODUCTION OF A UNIT OF MEASURE AND MEASURING APPARATUS INTO THE IRRIGATION SYSTEM OF NORTHERN INDIA.

I have already had occasion to remark that I do not consider the information we are at present in possession of sufficient to warrant the expression of any dogmatic views, either as to the best unit of measure, or the best form of measuring apparatus to be introduced into our Indian irrigation system. That both points, however, deserve the most serious consideration, is not likely to be questioned; and more in the hope that my remarks may lead to a practical investigation of them, and be in some degree suggestive as to the points this ought to embrace, than as claiming to be at all decisive regarding them, I propose now referring briefly to these subjects.

The methods at present in use for issuing water from the canals of Northern India are the following:—

1st, By single outlets of masonry, made directly in the banks of the canal. In the establishment of these, the sole precaution observed is to limit the sectional area: there is no provision whatever regarding the pressure, the level of the sill of the outlet with reference to the canal-bed, nor are any other arrangements whatsoever made to insure constancy of discharge. The outlets are rectangular, and from 15 to 20 feet in length, so that they are in fact tubes of masonry, and no attempts that I am aware of have ever been made to determine, by actual experiments, the volumes of water passing through them.

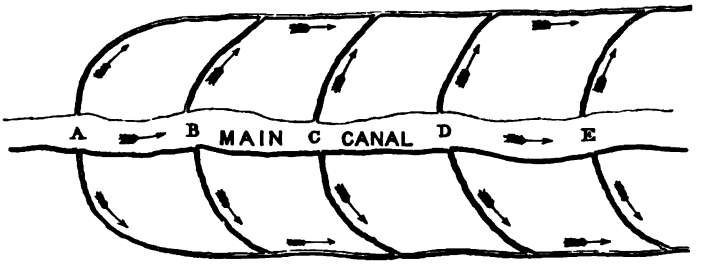
2d, By reservoir outlets—*i. e.*, simple outlets of large dimensions, terminating outside the canal-bank in reservoirs, in the sides of which several smaller outlets are established for the irrigation of separate estates. In these, new elements of disturbance are introduced in addition to those peculiar to single tubes, and they are equally devoid of securities for the maintenance of constant discharge.

3d, By rough wooden funnels or tubes inserted into the banks of the canal, having fixed heights and breadths, but otherwise altogether unregulated. This is a very miserable arrangement, and its evils have shown themselves so clearly that every effort is being made to remove all such funnels from the banks of main lines of canal, and to substitute for them the method of distribution next mentioned.

4th, By outlets, in a few cases of masonry, but in a very large majority, of wood, established not in the banks of the main canal, but in those of principal channels of distribution, locally termed *rajbuhas*, from two vernacular words meaning chief water-courses.

Among the provisions recommended by the Canal Medical Committee, to which the investigation of the sanitary relations of canal irrigation was intrusted, is one for insuring on all new canals, and especially on the grand canal of the Ganges, that no irrigation outlets whatever should be established on the main lines, but that the distribution of the water should be effected by means of a chain of chief water-courses on each side of the central lines. The diagram at the head of the following page will make my meaning clearer :—

CONNECTED CHAIN OF CHIEF WATER-COURSES.



CONNECTED CHAIN OF CHIEF WATER-COURSES.

A B C D E represents a main or central line of canal, such as that of the Ganges. Instead of small outlets at innumerable points along the banks, there are established at A, B, C, D, and E, distant from each other two, three, or more miles, according to local circumstances, heads of chief water-courses, with volumes of water regulated by special demand. The series on each bank is connected as shown in the diagram, so that no wastage occurs; the surplus water in each line passing onwards for the benefit of those at lower levels. In addition to the numerous sanitary and administrative advantages this excellent system affords, it has a peculiar advantage in greatly facilitating the introduction of a satisfactory measurement system. For if the quantity of water entering each of the chief water-courses is carefully regulated and controlled, I believe that the minor distribution to the separate estates dependent upon it would be found in practice a matter of comparative facility.

What would be the best unit of measure to adopt in this system is a point on which I am constrained to write under correction, for I feel the want of those numerical data by which its decision should be mainly determined. It appears to me, however, that a convenient, perhaps the most convenient, measure to adopt, would be the familiar one of a cubic foot per second. It would be

easy to calculate by existing formulæ the dimensions in height, breadth, and pressure to be given to an outlet which would have this discharge; but I confess I do not think any formulæ we now have are satisfactorily applicable to such canals of irrigation as we deal with in India; and before the above points are definitively adopted, I would recommend that experiments should be made to settle them on existing canals. I can see no difficulty, and very little expense, in carrying into effect this suggestion, and I hold it to involve a fundamental condition to the establishment of a satisfactory unit.

Supposing, however, the dimensions in height, breadth, and pressure, which would secure the closest possible approximation to the prescribed unit of one cubic foot per second, to have been determined, we find, from the statistics of irrigation in India, that this volume of water is sufficient for the irrigation, throughout the year, of very nearly 180 acres. By establishing, therefore, a decimal division of the unit, it would be possible to supply the wants of even the humblest cultivator, and a degree of accuracy would be introduced into our distribution system, of which at present it contains scarcely a trace.

In the estimate of the work done in irrigation by a cubic foot of water per second given above, all kinds of cultivation are included. But I need scarcely say that the consumption of water for different crops is extremely variable—rice, sugar, cotton, the cereals, &c., require each their special quantity, and I advert to the point to remark, that we are in great need of specific numerical data regarding it. When experiments are made to determine the dimensions proper to the unit of measure, means should therefore, I think, at the same time be taken to ascertain the average extent of irrigation it is capable of effecting with different crops, and on different

soils. Practical results of the highest value would follow the determination of such points—not, I may say, in rigid and absolute accuracy, which, from the infinite variety of local peculiarities, it would be impossible to attain, but with sufficient correctness for working purposes. I have been struck by the want of really good information on this branch of the subject throughout Northern Italy. With a minutely developed system of irrigation nearly seven centuries old, with a vast body of engineers constantly employed in its superintendence, it is wonderful how little has been done to determine, by direct observation and experiment, the effective work of given quantities of water applied to the irrigation of different agricultural products—some half-dozen experiments by Mari, De Regi, and the engineers who fixed the terms of the treaty for the use of the waters of the Tartaro in 1764, being continually repeated in all the many works I have searched for information on the subject; but of well-arranged and detailed series of observations, I have found no indications. It is not that data obtained in Northern Italy, in latitude and with products in many respects so different, could be of use in guiding us in India, but I was not prepared to find information, on a question of so much interest in itself, so singularly deficient. Such details as are recorded will be noticed more appropriately hereafter.

With the unit of measure introduced into our system, we should be prepared to establish an efficient measuring apparatus. The various details given in the preceding sections of this chapter furnish us with useful hints. Regard being had to local peculiarities, both as concerns the condition of the canals, the native establishments which must be employed, and the feelings of the agricultural community, it does not seem to me desirable to

multiply works of regulation requiring considerable outlay for their construction, and necessarily intrusted to parties in whose probity no great confidence can be placed. It therefore seems to me, that a single measuring apparatus for each chief water-course would be sufficient. This should, I think, be constructed with every possible precaution, to render it as nearly correct in its action as possible. I would not insist on the adoption of the specific form of the *modulo Milanese*, if local experience can suggest modifications calculated to improve it, and to adapt it to local wants; but, so far as I know, the principles on which this form is founded are the best yet developed. With modifications of dimensions to suit our own unit of water and linear measures, there is not a single precaution adopted in the Milanese system for insuring the constancy of discharge which I would willingly see neglected. One of the main objections to this system, stated by Tadini, is the disturbing effect on the water within the apparatus due to its position immediately on the bank of the main canal, the rush of the water from which makes the maintenance of a constant height of pressure on the measuring orifice a matter of considerable uncertainty. A special arrangement proposed for correcting this source of error, is to remove the measuring apparatus to some distance from the canal bank. There is another, and equally important, reason for doing this on canals in India. The operation of any measuring apparatus placed directly on the bank of the canal, or attached to the head of the chief water-course, would inevitably be affected by the deposit of fine sand, which invariably takes place there. This deposit, so far as my own observation extends, ceases to be *practically* mischievous at a distance of about half a mile from the head; and for this distance, the surface level of the water in the channel is usually so much below that of the

soil as to make irrigation impracticable. The proper distance, however, is a point to be established by experience in each case; and when it is so determined, the position of the measuring apparatus can be fixed with reference to it. When thus removed from the main line, the disturbing influence on the water within the *modulo* would be reduced to a minimum, and that of the silt deposits would be eliminated altogether. Continued observation on the part of the European executive officers would readily establish the ratio between the variations of level outside the apparatus, and the changes of the head of pressure over the measuring orifice dependent thereon; and by the application to the regulating sluice of an arrangement analogous to the Milanese *gattello*, an efficient control over the supply would be secured. The number of complete works for measurement being restricted to one for each chief water-course, the keys of the *gattelli* might, perhaps, be kept by the executive officer and his European assistants, whereby the native establishment would have no power over the supply of the principal lines. In all cases in which chief water-courses are made at the joint expense of several village communities or landed proprietors, I am of opinion that Government should invariably construct, at its own cost, the head of supply and the measuring apparatus, so as to maintain an indisputable right to these works, and thereby to vest in the hands of its own officers, the entire regulation and control of the water prior to its being issued to the cultivators. After it has been so issued, the less Government officers interfere with it the better.

As regards village water-courses, or minor distribution lines from the chief water-courses, I think the measuring apparatus should be the simplest and most economical possible, consistent with fair protection to the interests of

the State. To allow the present wretched system to continue, much less to extend, seems to me impossible; and in considering the arrangements to be substituted for it on existing, and to be introduced on new, canals, I am disposed to think the following would be the best, considering them, of course, open to correction, by the larger experience or better knowledge of parties on the spot.

Minor channels of distribution, numbering, as they will do, by thousands, require measurement apparatus independent of more than occasional inspection and control. The main supply of each chief water-course being carefully regulated under the inspection of the government officers, the small channels derived from it can never obtain either very much more, or very much less, than their prescribed volume. For them I therefore think that a small masonry-work—as no wooden constructions for the measurement of water ought on any account to be tolerated—consisting of the following elementary parts, would suffice: 1st, A head or outlet fitted with a sluice for opening or closing; 2d, A rectangular chamber, about 10 or 12 feet in length, and in breadth varying according to the size of the outlet; and 3d, A measuring orifice at the lower extremity of the chamber, invariably cut in a slab of stone from 3 to 4 inches thick, and having the constant height due to the unit of measure, and the breadth variable according to the number of units, or parts of a unit, it is designed to discharge. The specific dimensions it would be best to employ should, I think, be subject of special inquiry, as ought also sundry minor arrangements of this simple apparatus. These I do not attempt to prescribe, wishing merely to indicate in general terms the provisions which, at the minimum of cost and trouble, would secure practically the interests both of the

proprietors of the water and the cultivators of the land, introducing, at the same time, the elements of order, which admit of progressive improvement, into a system at present very chaotic.

SECTION V.

ON MEASUREMENT OF WATER IN PIEDMONT AND LOMBARDY BY HORARY ROTATION (ORARIO).

It will probably be a long time before the relation between supply and demand for water from canals of irrigation becomes such in India as to lead to the introduction of all those minutiæ of distribution which have grown up in Italy during the seven centuries that have passed away since the modern system of irrigation originated there. But looking to the avidity with which water is employed under a tropical sun, to its absolute necessity for agricultural purposes, and to the fact that the demand must, in course of time, become inevitably so great as to require the most minute economising of the supply, I have no doubt that the plan of distribution by horary rotation will ultimately become as prominent a feature in Indian as it now is in Italian irrigation; and therefore I think a short reference to it will not be misplaced here.

The period of rotation, locally termed the *ruota d'acqua*, necessarily varies according to the nature of the cultivation —rice, for example, requiring a more rapid rotation than meadow land; and so on.

The rotation, as a general rule, however, ranges between seven and sixteen days, rarely, except in the case of rice cultivation, falling below the former, or passing beyond

the latter period. The consumers of the water receive the full available volume, carried by the irrigating channel, for such number of hours as may best be suited to the special wants of each, and it is usual to enter into written agreements among themselves to regulate all points which might give rise to disputes. I give here an example of such an agreement, which affords a clear illustration of the system.

HORARY DISTRIBUTION TABLE, for the Year 1851, of the WATER of the IRRIGATING CHANNEL, X, carrying 24 cubic feet per second, of which the period of Rotation is 8 Natural Days, or 192 Hours.

Number.	Names of Cultivators.	Number of Hours for each.	Commencement of Horary Distribution.		Termination of Horary Distribution.	
			Hour.	Day.	Hour.	Day.
1	Proprietor A	14	4 A.M.	1st April	6 P.M.	1st April
2	„ B	16	6 P.M.	Do.	10 A.M.	2d „
3	„ C	24	10 A.M.	2d „	10 A.M.	3d „
4	„ D	18	10 A.M.	3d „	4 A.M.	4th „
5	„ E	2	4 P.M.	4th „	6 A.M.	4th „
6	„ F	25	6 A.M.	4th „	7 A.M.	5th „
7	„ G	30	7 A.M.	5th „	1 P.M.	6th „
8	„ H	23	1 P.M.	6th „	12 M.	7th „
9	„ I	19	12 M.	7th „	7 A.M.	8th „
10	„ K	21	7 A.M.	8th „	4 A.M.	9th „
	Total of hours	192	The rotation again commences in the same order with A.			

The civil code of Sardinia has provided against most of the causes of dispute to which such a system as this might give rise. Thus, in Art. 645, it is fixed that, in distributions of water by day and night, the natural day and night are implied; and that, as regards the use of water on festival days, those festivals only which may be in existence when the agreement was entered into are to be taken notice of. In Art. 646, it is prescribed that the time taken by the water to reach the channel of any cultivator or employer shall be included in his period, and that the surplus water, (*coda d'acqua*), which may pass down

the principal canal between the period of each consumer, appertains to him with whom the rotation terminates. A third difficulty in this system of distribution is provided for in Art. 647, which prescribes that no consumer has any right to the spring or drainage water which may collect in the main canal. This belongs legally to the original proprietor of the water, and can be disposed of by him as he thinks best.

In the constant variations of wants incident to an extensive system of agricultural irrigation, there are an infinity of cases constantly occurring, which require modifications of such a method of distribution as that by horary rotation. The subject of these variations has consequently occupied much of the attention of the Italian engineers; and in the Notes to the work of De Regi on the use of the Parabolic Table,* there is a great number of examples given in illustration of them. It is not necessary for me to dwell on these at any great length; but as the system is widely diffused, and of considerable practical importance, it will perhaps be useful to advert to it briefly.

It is clear, from very simple considerations, that the quantity of water to which any single employer of a canal common to several, and regulated by horary rotation, is entitled, is in direct proportion to the total volume of the canal, and the number of hours during which he is entitled to possess it, and in reciprocal proportion to the number of days over which the rotation extends. Hence, by a simple proportion, we have the following general formula:

$$Q = \frac{N\,T}{R}, \text{ where}$$

Q is the quantity appertaining to a single consumer in continued discharge.

* "Metodo per la soluzione delle questioni relative all' uso delle acque, specialmente nelle irrigazione de' fondi regolate sugli orarii."—De Regi, p. 57.

T, the *orario*, or number of hours or days during which he has the right to the whole volume of the canal.

N, the volume of the canal in cubic feet or *once*, or any fixed measure.

R, the *ruota*, or number of days over which the rotation extends.

I borrow a few examples from De Regi to show the practical application of the above.

Ex. I. An employer of a common channel has a right to 6 cubic feet of water per second for six days in a rotation of fourteen days. He wishes to change this intermittent for a continued supply, the value of which is sought.

In this case $T = 6$, $N = 6$, and $R = 14$; whence,

$$Q = \frac{6 \times 6}{14} = \frac{36}{14} = 2\tfrac{4}{7} \text{ cubic feet per second.}$$

Ex. II. An employer has the right to a continued discharge equal to 3 cubic feet per second, and he is allowed to make use of an outlet having a discharge of 12 cubic feet, with a period of four days. What ought to be the duration of the rotation to give him an intermittent quantity, under these conditions, equivalent to the continued discharge to which he has a right?

From the equation $Q = \frac{NT}{R}$ we have

$$R = \frac{NT}{Q} = \frac{12 \times 4}{3} = \frac{48}{3} = 16$$

Hence a discharge for four days of 12 cubic feet in a rotation of sixteen days, is equivalent to the continued discharge of 3 cubic feet.

Ex. III. An employer having a continued discharge of 4 cubic feet, desires to effect an exchange with another who has a right to 20 cubic feet per second, for a certain

time in a rotation of fifteen days. What ought the time to be to make the two volumes equivalent?

$$T = \frac{RQ}{N} = \frac{15 \times 4}{20} = \frac{60}{20} = 3 \text{ days.}$$

Hence the periodic discharge of 20 cubic feet per second for three days in fifteen, is equivalent to the continued discharge of 4 cubic feet.

It is sometimes desirable to be able to compare the rights of two or more consumers, or the quantities of water to which they may be respectively entitled. Thus—

Ex. IV. An employer, A, of a certain canal has a right to 6 cubic feet of water for six days in a rotation of fifteen; another employer, B, desires to have a supply quadruple that of A, but he can only have the use of it for five days in a rotation of twelve. What is the quantity of water adapted to his wants?

The ratio of $\frac{nt}{r}$ to $\frac{NT}{R}$ is in this case as 4 to 1. Hence

$$1 : 4 : : \frac{NT}{R} : \frac{nt}{r} : : \frac{6 \times 6}{15} : \frac{5n}{12} : : 144 : 25n$$

Or, $\begin{matrix} 25n = 576 \\ n = 23\frac{1}{25} \end{matrix}$

Hence the requisite quantity B should have is $23\frac{1}{25}$ cubic feet per second for five days in a rotation of twelve.

Ex. V. An employer who possesses 7 cubic feet of water for six and a half days, in a rotation of fifteen days, wishes to change it for another of 10 cubic feet in a rotation of fourteen days. What ought the horary or diurnal period to be?

In this case the two volumes should be equal. Hence,

$$Q = q \text{ \& } \frac{NT}{R} = \frac{nt}{r}$$

$$\text{Or, } t = \frac{rNT}{Rn} = \frac{14 \times 7 \times 6\frac{1}{2}}{15 \times 10} = 4.247$$

Or the period sought ought to be about four days five hours and six minutes.

Ex. VI. A volume of water equal to 20 cubic feet per second is employed in a rotation of twelve days. It belongs to three proprietors, A, B, and C. A has the right to it for six days, B for four, and C for two. B and C introduce, at their exclusive expense, a new supply of 8 cubic feet, making the total volume 20 cubic feet, and change the period of rotation to fourteen instead of twelve days. A having no right to any portion of the new supply, which is equally divisible between B and C, it is required to determine the time during which the first-mentioned proprietor, A, is entitled to enjoy the full supply, so that none of the parties may suffer loss.

Here the quantity due to A must be the same both before and after the introduction of the new volume. Hence

$$\frac{20 \times 6}{12} = \frac{28\,T}{14} \;\&\; T = \frac{20 \times 6 \times 14}{12 \times 28} = 5 \text{ days.}$$

Or A has the right to five days' enjoyment of the full supply of 28 cubic feet in a rotation of fourteen days, instead of six days' enjoyment of 20 cubic feet in a rotation of twelve days.

As regards the right of B, since he is entitled to half the new volume, it is clear that his original share, increased by 4 cubic feet, must be equal to the quantity sought under the new arrangements. Hence

$$\frac{4 \times 20}{12} + 4 = \frac{28\,T}{14} \text{ or } \frac{32}{3} = 2\,T \text{ or } T = 5\tfrac{1}{3} \text{ days.}$$

So that B has a right to $5\frac{1}{3}$ days of the new rotation of fourteen days.

Similarly it will be found that the third proprietor, C, is entitled to $2\frac{2}{3}$ days of the modified period.

In agreements for water by rotation, the element of price constantly enters; and it may be useful to show, by one or two examples, how this is calculated.

Calling P the price of the water per cubic foot, or any other unit, we have, by multiplying both sides of the equation formerly given—

$$PQ = \frac{PNT}{R}$$

wherein the first term shows the value of the share of any proprietor in continued, and the second the same in periodic, discharge. Expressing the former by U, we have the general expression—

$$U = \frac{PNT}{R}$$

Ex. VII. A proprietor of a canal having a volume of 9 cubic feet per second, has farmed it to an employer, under the condition that he shall have the enjoyment of the entire volume for four days in a rotation of twelve days, at the rate of £30 per cubic foot of continued discharge. What sum must the employer pay?

$$U = \frac{PNT}{R} = \frac{30 \times 9 \times 4}{12} = \frac{1080}{12} = £90.$$

Ex. VIII. An employer of a canal has paid £90 for the enjoyment, during three consecutive days, of a volume of water, which is issued in a rotation of twelve days, and at a rate of £30 per cubic foot. What number of cubic feet ought he to have?

Since $U = \frac{NTP}{R}$, we have $N = \frac{UR}{TP}$,

Or $N = \frac{90 \times 12}{3 \times 20} = \frac{1080}{90} = 12$ cubic feet.

Ex. IX. A cultivator pays £90 for the rent of a canal carrying a volume of 10 cubic feet per second for four consecutive days, in a rotation of fifteen days.

What ought he to pay as the rent of 1 cubic foot of continued discharge?

$$P = \frac{RU}{NT} = \frac{15 \times 90}{10 \times 4} = \frac{1350}{40} = £33, 10s.$$

Ex. X. There is paid for the use of 8 cubic feet of water per second for six consecutive days, the sum of £120, at the rate of £30 per cubic foot. What ought the rotation period to be?

From the equation $U = \frac{NTP}{R}$ we have

$$R = \frac{NTP}{U} = \frac{8 \times 6 \times 30}{120} = 12 \text{ days.}$$

When any minute subdivision of water takes place, it is occasionally necessary to enter into agreements by the hour, and I may now give an illustration or two of the methods of calculation employed in such cases :—

Since $U = \frac{NTP}{R}$, we have, by reducing the days to hours, $\frac{U}{24T} = \frac{NP}{24R}$, in which the first term gives the value of an hour in the horary period. Designating this by V, we have $V = \frac{U}{24T}$, or $\frac{PQ}{24T}$; and hence $V = \frac{NP}{24R}$.

By simple substitution of the different values of Q, U, and V, a variety of questions constantly occurring in practice may be solved; as, for example,

$$Q = \frac{24TV}{P} : U = 24TV : V = \frac{U}{24T}$$

Ex. XI. What is the value of one hour's supply of water from a canal carrying 13 cubic feet per second, distributed in a rotation of fourteen days, the price per cubic foot being £30?

Here $N = 13 : R = 14 P = 30$

$$V = \frac{NP}{24R} = \frac{13 \times 30}{24 \times 14} = \frac{390}{336} = £1, 8s. 9d.$$

Ex. XII. What ought to be the price per cubic foot of a volume of water, consisting of 6 cubic feet, distributed in a rotation of fourteen days, and costing £1 per hour ?

$$P = \frac{24\,R\,V}{N} = \frac{24 \times 14 \times 1}{6} = \frac{336}{6} = £56.$$

Ex. XIII. What ought to be the period of rotation for a cultivator who, for the use of a canal containing 10 cubic feet per second, at the rate of £30 per cubic foot, pays £1 per hour ?

$$R = \frac{P\,N}{24\,V} = \frac{30 \times 10}{24 \times 1} = \frac{300}{24} = 12\tfrac{1}{2} \text{ days.}$$

In the appendix to De Regi's work there is a large collection of problems, similar in character, though differing in detail, to those now given. I do not, however, see any necessity for giving more, as I believe those already noted will sufficiently illustrate the system of distribution by horary rotation, and will furnish the means of applying it in practice, should circumstances require this to be done on the canals of India.

CHAPTER II.

EMPLOYMENT OF WATER FOR IRRIGATION IN THE AGRICULTURE OF NORTHERN ITALY.

SECTION I.

SUMMER MEADOW IRRIGATION.

THE traveller in the central valley of the Po is familiar with those vast plains of meadow-land which form the characteristic feature of the agriculture of that region, and supply food for the cattle, on which the wealth of the irrigated districts is so materially dependent.

These meadows are locally divided into two principal classes, the permanent and the temporary—meaning by the latter term such as are introduced into the rotation of crops adopted in the irrigated region. Of the permanent, there are two kinds, the summer and the winter meadows—*prati irrigatorii simplice* and *prati marcitorii*. The permanent summer-meadow, being that which is under irrigation from the end of March to the middle of September, is now restricted; and so much advantage has been found from introducing the temporary meadow in rotation with other crops, that the former is used only in localities not well adapted for general cultivation. The winter-meadows are peculiar to Italian agriculture; and

as being so, it may be worth while to give presently some details regarding their formation and maintenance.

In adapting land either for permanent or temporary summer-meadows, the general principles to be followed are few and simple. It is essential that the surface should be so disposed as that each part of it should receive readily the water from the main channel of distribution. In practice, this is effected in all possible cases, by taking advantage of such natural inequalities of level as admit of the water being delivered from culminating lines. Where nature is not so favourable, the soil is lowered in some places and raised in others, until the requisite condition has been obtained. The extent to which this latter process has been carried, especially in Lombardy, is very remarkable. In one of the estates I saw near Milan, excavation in one place and raising in another were in progress over an extensive area, ranging from 3 to as much as 5 feet in depth; and I was informed by the proprietor that he anticipated an expenditure for this single operation of from £10 to £12 per acre. This, however, I must add, was not an average case, and is referred to here simply as an illustration of the extent to which the system may be carried, with reasonable hope of a fair return in time on the capital expended.

It is farther requisite that the water should spread itself in a thin uniform sheet over the surface of the land. This is effected by disposing the soil in gently inclined planes, the dimensions of which vary exceedingly, according to the practice of different localities, and also according to the peculiarities of the soil. Where the land is very light and absorptive, the planes, locally termed *ale*, have a breadth sometimes as low as from 25 to 30 feet; while in heavy retentive soil, this dimension is in-

creased to eight and even ten times these numbers. Colombani mentions,* that for summer-meadows in the province of Lodi the breadth in the direction of the slope is 140 metres, or nearly 460 feet, while the length in the direction transverse to the slope is 180 metres, or 590 feet, which would make each of the great compartments contain an area of about 6 acres English. To each such compartment a main irrigating channel, of about 3 feet in breadth, running in a direction transverse to the slope, is allotted; and in summer-meadow it is not usual to have minor channels, unless special local circumstances render them absolutely necessary. The slope given to the surface of the meadow is, when practicable, two-tenths per 100; or, in English measure, about 3 inches in each 100 feet. It must, however, be remarked that, in travelling through the irrigated districts, I found an interminable variety of dimensions in every part of the system of irrigation; and, in fact, all such details are regulated in Northern Italy rather by a sort of practical instinct on the part of the *campari*, or men to whom the distribution of water is intrusted, than by any established or universally received rules. Such specific numerical statements as I may give here, are therefore to be regarded merely as averages.

A third provision essential to the efficiency of meadow irrigation is to have ready means of drainage, so as to prevent any stagnation of the water on the land. To secure this, a drainage channel is carried along the base of the slope of each compartment, parallel to the main irrigating channel, into which the surplus water is collected and carried off by some natural line of discharge, or, as is far more generally the case, made available for the irrigation of another compartment at a lower level. The

* *Idrodinamica*, p. 189.

importance attached to these drainage or surplus waters, locally termed *colatori*, is very great throughout the whole of the irrigated region. Passing over lands richly manured, as they universally do, they become charged with fertilising matter, and have a value often considerably superior to their original one. Their temperature also becomes higher than when issuing directly from the canals; and this is found to act as a powerful stimulant on the production of the grass. In subordination to the general topographical features of the country, the compartments of the meadow lands are, whenever practicable, made to slope from north to south; the irrigating and drainage channels, accordingly, running from east to west. It is not, of course, always possible to carry this arrangement into effect; but the advantage of having the land to be irrigated inclined similarly to the canals of irrigation, is so manifest that it is always thus disposed when it can be done.

From the article on agriculture in the work entitled "*Milano e il Suo Territorio*," I have derived the following details regarding the produce of permanent summer-meadows. These meadows are cut thrice during the season, and each cutting supplies a kind of hay distinguished by a peculiar name. The first cutting in May is termed *Maggengo*; the second in July, *Agostano*; and the third about the end of August, or beginning of September, *Terzuolo*. The grass growing after the third cutting, which is termed *Quartirola*, supplies pasturage to the cattle at the end of autumn. If irrigation is commenced very early in spring, some lands supply four crops, the second being distinguished as *Magghengino*. The annual production may be calculated as follows, in English measures, assuming the *fasci* of Milan to be equal, as they very nearly are, to $1\frac{1}{2}$ cwt. each.

	Cwt.	
Hay from first cutting, . . .	24.375	per acre.
Do. from second do. . . .	18.5	do.
Do. from third do. . . .	13.9	do.
Total of hay per acre, . .	56.775	

The value of the pasturage of the *quartirola* is about eight shillings per acre, and the average price of hay in the irrigated districts may be taken at 2s. 6d. per cwt. The gross value of the produce of an acre of permanent meadow in Lombardy would therefore be about £7, 8s. per annum. The expenses will be indicated hereafter.

The temporary summer-meadows (*prati a vicenda*), or those which are introduced into the rotation of crops, are arranged similarly to the preceding in all that regards irrigation. The essential conditions in both cases are the same, only in one the land remains continuously under grass, while in the other it is so only for two or three years. The ordinary period of rotation is for five years, in the following order :—

First year, wheat, cut about the middle of July, grass seeds being sown with the wheat. 2d, 3d, and 4th, Meadow under irrigation, and abundantly manured. 5th, Indian corn or flax. After flax, cut at the end of June, millet is immediately sown, and comes to maturity about the end of October of the same year. A sixth year is occasionally added to the period, when another crop of Indian corn is taken, and the rotation again commences in the same order.

In illustration of several points connected with this subject, I may give here the following comparative statement of expenditure and return from irrigated and unirrigated lands in the Lumellina, which is one of the best irrigated districts of Piedmont. They were prepared by an excellent authority, a gentleman in charge of a number

of the canals in the provinces of Mortara and Novara, and are the results of actual experience on a property consisting of 3750 acres. I believe, therefore, they may be accepted as tolerably correct. The originals being all in Piedmontese measures, I have reduced them throughout to their equivalents in our own.

COMPARATIVE STATEMENT of EXPENSES and RETURNS from IRRIGATED and UNIRRIGATED LAND in PIEDMONT.

YEAR.	NATURE OF CULTIVATION.	EXPENSES.	RETURNS.
First Year.	1st, Culture of one acre of good strong land in the usual rotation of five years—*Without Irrigation.*		
Indian corn.	*Manuring.* — Purchase, carriage, and spreading of 135 cwt. of stable manure, at 4½d each, . . .	£2 10 6	
	The ploughing and harrowing are executed in return for the grass and the gleaning of the Indian corn after the harvest. Other field-work is paid for *en metayer*, with one-fourth of the produce.		
	Produce in grain, deducting seed and the portion due to the *metayer*, 21.6 bushels, at 3s. 4d. each, . .	. .	£3 12 0
Second Year.	Manure, two-thirds of the quantity used the first year, . . .	1 13 8	
Legumes.	Three ploughings and horrowings, at 4s., ...	0 12 0	
	Produce in legumes, deducting seed and portion due to the *metayer*, 18 bushels, at 3s. 11d. each, . .	. .	3 10 6
Third Year.	One ploughing and harrowing, at 4s.,	0 4 0	
	Produce in straw, ...	. .	0 8 0
Wheat.	Do. in grain, deducting seed and portion due to the *metayer*, 17.16 bushels, at 5s. 10d. each, ...	. .	5 0 1
Fourth Year.	Four ploughings and harrowings, at 4s., ...	0 16 0	
	Manure, as in the first year, . .	2 10 6	
Wheat.	Produce equal to that of the third year—viz.,		
	Straw, ...	. .	0 8 0
	Grain, ...	. .	5 0 1
	Carry forward,	£8 6 8	£17 18 8

Year.	Nature of Cultivation.	Expenses.	Returns.
	Brought forward, .	£8 6 8	£17 18 8
Fifth Year.	Four ploughings and harrowings, at 4s., ...	0 16 0	
	Produce in straw, ...	. .	0 8 0
Rye.	Produce in grain, deducting seed and portion due to the *metayer*, 17.16 bushels, at 3s. 4d., ...	. .	2 17 2
		£9 2 8	£21 3 10
	Deduct expenses, ...	. .	9 2 8
	Net returns for five years, .	. .	£12 1 2
	Annual return per acre, ...	£2 8 2	
Means of three Years.	2*d*, Culture of the same land as the preceding, converted into an irrigable meadow. The averages of three years are given.		
Meadow.	*Manure.*—150 cwt. of stable manure, at 4½d. each, ...	£2 16 3	
	Charges for irrigation channels and spreading manure, ...	0 12 6	
	Watering, cutting, making, and carriage of hay, ...	1 7 8	
	Produce of three cuttings, 72 cwt. of hay, at 2s. 4d. each, ...	. .	£8 8 0
	Rent received for pasturage after the third cutting, ...	. .	0 8 4
	Totals, ...	£4 16 5	£8 16 4
	Deduct expenses, . . .	. .	4 16 5
	Net annual produce of one acre of irrigated meadow, ...	. .	£3 19 11
	Comparative Statement.		
	Annual produce of one acre of irrigated land, ...	£3 19 11	
	Annual produce of one acre of unirrigated land, ...	2 8 2	
	Excess per acre in favour of irrigation,	£1 11 9	

The preceding details show results on strong good land in the Lumellina. It may be interesting to give an example of the same kind for light and rather inferior soil in the same locality.

Year.	Nature of Crop.	Expenses.	Receipts.
	1*st*, Culture of an acre of light and sandy soil in a rotation of four years—*Unirrigated.*		
First Year.	Manure as in No. 1, ...	£2 10 6	
Indian corn.	Labour is paid for *en metayer*, as in No. I., with one-fourth of the produce.		
Second Year.	*Net produce*, deducting portion due to the *metayer* and seed, 16.7 bushels, at 3s. 4d. each, ...	. .	£2 15 8
	Manure equal to first year, . .	2 10 6	
Legumes.	Three ploughings and harrowings, at 3s. 4d. each, ...	0 10 0	
Third Year.	*Net produce*, 14½ bushels, at 3s. each,	. .	2 16 9
	Ploughing and harrowing, . . .	0 3 4	
	Net produce, ...	. .	2 9 7
	Straw, ...	. .	0 6 8
Rye.	Five ploughings and harrowings, at 3s. 4d., ...	0 16 8	
Fourth Year.	*Net produce*, ...	. .	2 9 7
	Straw, ...	. .	0 6 8
Rye.	Totals, . . .	£4 0 6	£11 4 11
	Deduct expenses, . . .	. .	4 0 6
	Net returns for four years, . .	. .	£7 4 5
	Annual return per acre, . . .	£1 16 1	
	2*d*, Culture of an acre of the same land as the preceding, converted into an irrigated meadow. Averages of three years.		
	Manure.—150 cwt. of manure, at 4½d. each, ...	£2 16 3	
	Cost of irrigated channels and spreading manure, ...	0 12 0	
	Cost of watering, cutting, making, &c.	1 2 9	
	Produce of three cuttings, 60 cwt. of hay, at 2s. 4d. each, . . .	. .	£7 0 0
	Received for pasturage after third cutting, ...	. .	0 5 0
	Totals, . . .	£4 11 0	£7 5 0
	Deduct expenses, . . .	. .	4 11 0
	Annual net return of one acre of irrigated meadow, ...	. .	£2 14 0
	Comparative Statement.		
	Annual net produce of one acre of irrigated land, ...	£2 14 0	
	Annual net produce of one acre of unirrigated land, ...	1 16 1	
	Excess per acre in favour of irrigation,	£0 17 11	

The preceding details apply to summer irrigation in Piedmont. The following show the net rent derived from a farm of about 350 acres thoroughly irrigated, in the province of Milan :—

Rent in money paid to the landlord per acre,				£1	19 6
Minor items paid in kind,				0	1 3
Communal (parish) charges paid by the tenant,				0	1 8
Government charges paid by tenant,				0	9 4
Proceeds of sale of wood reserved by the landlord,				0	1 9
Gross rent per acre,				£2	13 6
Deduct proportion of expenses paid by the landlord as follows :—					
Government and communal charges,	£0	11	0		
Repairs of buildings and hydraulic works,	0	2	9		
Expense of administration, inspections by engineers, &c.,	0	2	0		
				0	15 9
Net rent per acre,				£1	17 9

Such land as is referred to in these details, sells for from £40 to £45 per acre; so that the interest on capital thus invested does not much exceed 4 per cent. The gross returns from irrigated meadow land in the Milanese have formerly been estimated at £7, 8s. per acre; and if these data are to be depended upon, it would appear that the rent is just one-fourth of the total amount of these returns.

As regards the quantity of water to be given to meadow land, there is great variety of opinion, as might be expected in a matter dependent on so many variable elements. There are three ways in which this quantity is estimated: 1st, By the volume of water in continued discharge required to irrigate a given area of land; 2d, By the total depth of water spread over the soil, either at each watering, or during the whole season of irrigation; 3d, By the total cubic contents of the mass of water employed.

According to an experiment of De Regi, the details of

which I reduce to English measures, the continued discharge of 1 cubic foot per second is sufficient for the irrigation, in twenty-four hours, of 4 acres. Hence, as the total volume discharged during that time amounts to 86,400 cubic feet, and the area watered to 174,240 square feet, it appears that a stratum of water, equal to nearly 6 inches in depth, was in this case spread over the surface of the meadow. And as the general period of rotation may be taken at fourteen days, it would thence appear that a continued discharge of 1 cubic foot per second would suffice for the irrigation of (12 × 4) 48 acres of meadow land, there being precisely twelve periods of fourteen days each in the season of summer irrigation. The above estimate, however, implies that the whole water is absorbed by the soil, which, in point of fact, is never the case. Lombard engineers calculate the absorption in each watering as ranging from one-half to one-third of the total quantity of water employed. Hence, supposing it to be the larger of these proportions, it appears that after the irrigation of 48 acres had been effected, half a cubic foot would be available, as what is locally termed *colatori*, for farther employment, and similarly in successive series till the entire quantity was exhausted. Effectively, the irrigating power of any given quantity of water employed in meadow irrigation, is held by practical men to be equal to twice the area watered on the first application. According to De Regi's experiments, therefore, 1 cubic foot of water, perfectly economised, would be sufficient for the irrigation of 96 acres of permanent or temporary meadows.

In the article on the agriculture of irrigated Lombardy, formerly quoted, it is stated that (reducing the numbers to English equivalents) 1 cubic foot of water is sufficient for the irrigation, in the ordinary period of rotation, of 38

acres only; or, if account be taken of the surplus waters, of twice this quantity—being 76 acres in all.

It is usual, in grants of water made at the present day throughout the provinces of Verona and Mantua, to adhere to the data established by the treaty of 1764, between the Venetians and the Austrians, for regulating the distribution of the waters of these districts. The period of rotation here is stated to be seven days; and according to one series of experiments, a cubic foot per second would be sufficient for the irrigation of $3\frac{1}{2}$ acres in 24 hours, or for $22\frac{1}{2}$ in periods of seven days; while by another series, under more fortunate circumstances, these numbers are just doubled. Hence, in this instance, it would appear that, taking an average, and supposing the entire surplus waters economised, the effective irrigating power of a cubic foot per second would be very nearly 68 acres, and proportionally more as the period of rotation was extended.

Finally, Tadini mentions, as the result of numerous experiments made by him on the irrigation of meadows, that a mass of water equal to 35,000 cubic feet is sufficient for an area of 107,100 square feet, being a stratum of about $3\frac{1}{4}$ inches at each watering, which would give an effective power to the cubic foot equal to that established by De Regi, or about 96 acres.

It may, therefore, I think, be safely concluded, that a stratum of water about 4 inches deep, leaving half the quantity in the soil, and the other half available for farther use, would be abundant in all cases; and if provision to this extent be made, the differences due to variety of soil and other circumstances would be sufficiently provided for.

In conclusion, I may note that, after summing up the results of experience in France and Italy, M. de Buffon comes to the conclusion that the irrigation of an acre of meadow requires, under average circumstances, the con-

tinued discharge of 18½ cubic inches of water, which gives an effective power per cubic foot per second of 93 acres; and this I believe to be a very close approximation to the truth, as the following summary shows :—

De Regi's estimate,	. .	96 acres per cubic foot per second.	
Milanese do.,	. . .	78	„ „
Veronese and Mantuan do.,	.	68	„ „
Tadini's do.,	. . .	96	„ „
Buffon's do.,	. . .	93	„ „

SECTION II.

MARCITE OR WINTER-MEADOW IRRIGATION.

Viewed in reference to its superficial area, the winter irrigation of Italy is extremely limited, not exceeding in Lombardy and Piedmont from 12 to 15,000 acres. The great mass of the water consumed there is spread over the land between the middle of March and the beginning of September; for the remainder of the year it does no more than maintain the above-mentioned limited extent of winter meadow. In this point of view the contrast between the irrigation systems of Italy and India is striking. The winter harvest of the latter, or that sown about October or November, and reaped in April or May, is, as respects irrigation, by far the most important. While the Italian cultivator rarely has occasion to irrigate any of the corn-crops except the maize, these products would in India be inferior equally in quality and quantity without the use of water; and hence it is that during the entire year irrigation is in demand. The periodic rains modify to some extent, and even occasionally supersede, the necessity for water during the latter summer months,

or from July to September; but as rice and sugar-cane must always be irrigated, the water cannot be considered idle even within these limits. It thence arises that the average area of irrigation in India is considerably in excess of that in Italy. We have seen, at the close of the preceding section, that about 90 acres is the average extent of ordinary irrigation by 1 cubic foot per second in the latter country. In India, the statistics of the canals there show that the same quantity of water, being employed during the whole year, does, so to speak, just twice the work, the area irrigated by a continued discharge of one foot being equal to 180 acres. We have no data by which we can reduce this quantity, so as to show the elements of which it is composed. It is merely a general average obtained by dividing the total area watered by the volumes of the canals employed. There is, however, no species of cultivation in India or elsewhere, that I am aware of, similar to the *marcite* of Northern Italy, the quantity of water required for which is enormous, and the details of the cultivation altogether peculiar. I propose, therefore, giving in this section some details illustrative of this remarkable species of culture, for which I am indebted chiefly to a work by Signor Dominico Berra, entitled *Dei Prati del Basso Milanese detti a Marcita*, published at Milan in 1822. In my travels through the irrigated districts, I was constantly referred to this book as containing the best account of the winter meadows yet extant.

The right to water for winter irrigation commences on the 8th of September, and terminates on the 25th of March. It is essential to the establishment of a winter meadow, *a marcita*, that entire command over the water should be held by the proprietor; for intermittent irrigation is not adapted to this species of culture. Continuous irrigation, suspended only for the time required to cut the

grass, is the first requisite for entire success. The water thus employed is derived either from the ordinary canals of irrigation, from springs, from the smaller streams, or lastly, from the surplus or drainage of other irrigated lands at higher levels. Of these sources of supply, the springs and the drainage waters are the best. It is essential to the success of a winter meadow, that the water employed should have as high a temperature as possible. Hence it is that the springs, being always warmer in winter than water freely exposed to the influence of the atmosphere, are preferred to any other means of irrigation during this season. In illustration of this point, Signor Berra mentions that, on the 14th February of the year in which his work was published (1822), the thermometer of Reaumur indicated, at six in the morning, an atmospheric temperature of —1°.5. On immersing the instrument in the tube (*tinello*) at the spring-head, it at once rose to + 10.5, showing a difference of 12° of Reaumur, or 27° of Fahrenheit, between the temperature of the spring and that of the external atmosphere. As the water passes to a distance from the spring, it of course parts with this excess of temperature; and hence it is invariably to be observed that the finest meadows are those nearest to the fountain-head. The water from the ordinary canals being generally about the same temperature as the air, does not produce the same stimulating effects on the *marcite*, with exception, however, to that which is collected in the Naviglio Interno of Milan, and the Vecchabbia. The water in these lines, passing through the subterranean channels of the town, and charged with an abundance of fermenting matter, is found not only to retain a higher temperature, but farther to stimulate the productive power of the meadows, by deposits so rich as to excel every other species of manure. So abundant are

these deposits, that the surface of the fields becomes speedily elevated by them, and it is necessary, at intervals of two or three years, to lower the levels so as to insure easy irrigation, The material thus removed is greedily sought by cultivators in the vicinity, as a most powerful and valuable manure. The supplies from canals present one material advantage over those from springs, in being practically invariable. As no *marcite* can possibly survive the want of water for even very short periods, the intermittent nature of the supplies from springs, which vary much with the variations of the weather, cause considerable uncertainty; and hence the canals, as being constant in this respect, are, in spite of their low temperature, in request with the cultivators.

The worst water of all for the use of winter meadows is that derived directly from such rivers as the Olona, Lambro, &c.; for not only is the temperature low, and the supply uncertain, but the deposits brought down after the rain are most injurious to the meadow produce, and to the cattle fed upon it.

The quality of the drainage-waters from other farms, as applied to *marcite*, depends upon the source whence they have originally been derived, and the nature of the soil, or the species of cultivation, over which they may have previously passed. The surplus waters of a well-tilled and richly-manured farm are more valuable than in their original condition, for they are charged with fertilising matter. It has hence become a rule in the establishment of a series of winter meadows at different levels, which are to be irrigated from the same source, to manure most richly those near the head of the supply, whether spring or canal, and to make the water itself the medium of conveying the manure to the others below. The presence of this manure is supposed to raise in some degree

the temperature of the water, a point always much insisted on by Lombard and Piedmontese agriculturists, who hold that, in proportion as the heat of the water becomes greater, so much better is it adapted for the kind of cultivation now under notice. The order of succession in quality of waters for *marcite* may therefore be stated thus—

1st, Sewerage canals, like the Vecchiabbia. 2d, *Fontanili*, or springs. 3d, Ordinary canals of irrigation. 4th, *Colature*, or drainage waters. 5th, Rivers, like the Olona, Lambro, &c.

The following are the details given by Signor Berra for the preparation of the land of winter meadows, as derived both from the practice of the most experienced Lombard farmers, and from experiments made on his own property.

Having cleared the land of weeds and roots of all kinds, it is ploughed and manured carefully in April, and Indian corn is then sown, as being the crop with which it is held to be best to prepare for the *marcite*, requiring, as it does, repeated weeding and clearance of the soil. The crop being reaped in October, the roots are carefully removed, the land ploughed and harrowed, and its surface smoothed as much as possible. In this state it is left until the beginning of January, when the works necessary for irrigation are commenced. It is of importance to the economy of these operations that they should be executed in winter, as labour is then more abundant and cheaper than at any other period of the year.

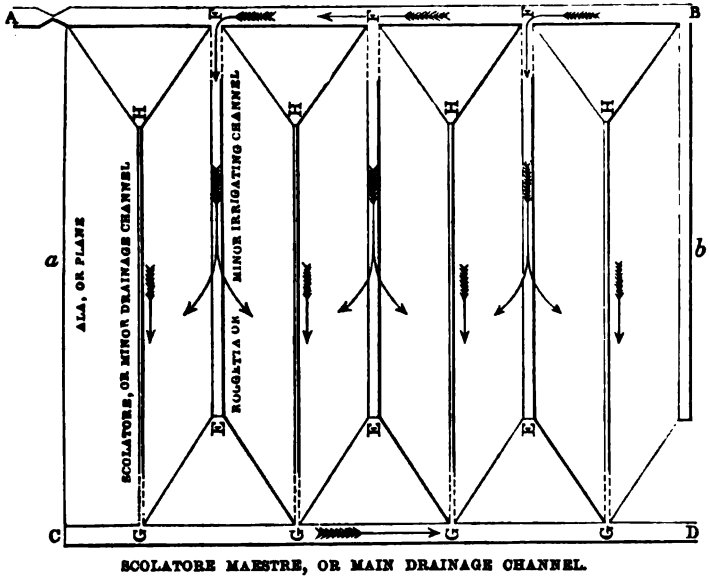
The assistance of the *camparo*, or the man charged with the distribution of the water, becomes necessary at this stage. Long experience and traditional rules have made this class of men very expert in all details of the minor works of irrigation. Most frequently they are guided in their levelling operations solely by the eye, and their instrumental apparatus consists of only a few pickets

of different lengths, and a line. With the assistance of these, the first step the *camparo* takes, is to mark out, on the highest level of the field, the direction and breadth of the principal irrigating channel, locally termed the *roggia adacquatrice*. The dimensions of this channel necessarily vary with the quantity of water available for distribution; but care should be taken to restrict them as much as possible, it being cause of complaint that such channels are almost invariably made too large, and a serious amount of good land is thereby lost. When the position of the main channel has been fixed, the field is then divided into a series of rectangular compartments, termed *piane* or *ale*, between each two of which, and at right angles to the main channel, there is established a minor irrigating channel, or *roggetta*. The breadth of each plane, in a well-constructed winter meadow, is never more than from 25 to 30 feet: the length is more variable, and depends on the quantity of water at command. It is usually, however, about eight or ten times the breadth. The planes slope from the minor channel on each side at the rate of .03 in 1 ; or when the breadth is 30 feet, the slope would be very nearly 12 inches. With this slope, the water passing from the main to the minor channels, is discharged from the latter in the form of a thin and ever-moving veil, which, flowing over the surface of the planes with just sufficient velocity to prevent congelation, supplies the grass with continual stimulus. In addition to the minor irrigating channels on the crests formed by each two planes, there are minor drainage channels established in the little valleys between the same, called *scolatori*, all of which discharge themselves into a main drainage channel carried along the lowest level of the meadow, called the *scolatore maestre*. The following diagram will illustrate the general arrangements for irrigation and

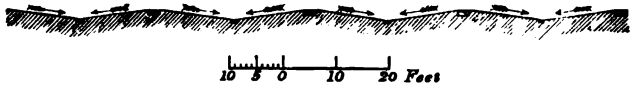
drainage. There are varieties of dispositions adopted in practice, according to local peculiarities of level, &c.; and of these I propose to give some illustrations in the Plates; but at present I restrict myself to a single general example.

ARRANGEMENT OF A MARCITE FIELD.

Plan.



SECTION ON *a b*.



A B, main irrigating channel.

C D, main drainage channel.

E F, minor irrigating channels, generally 12 inches wide, and 6 or 7 deep.

G H, minor drainage channels, about half the above dimensions.

Planes, from 25 to 30 feet in breadth, with a height at the crest of 12 inches.

The earth from the irrigating and drainage channels is spread over the planes with singular dexterity, so as to give them the requisite slope; and when these arrangements for irrigation are completed, another ploughing and harrowing are given, and the land is then left untouched until the end of February, or beginning of March, when it is once more ploughed, harrowed, and carefully cleaned of all weeds which may have shown themselves.

When it is necessary to level the field, a machine, called a *raggia*, being simply a large scoop drawn by two oxen or horses, is employed. It is managed after the fashion of a plough, and cuts off layer after layer of the more elevated parts of the land, the earth being then transported to those at a lower level, and deposited there. If levelling operations have been necessary, a fourth ploughing and harrowing are given after their completion, so as to prepare the soil for the seed. In April, oats are sown, with about 4½ bushels to the acre. After harrowing, clover and the *Lolium perenne** are sown in the proportions of one-fourth of a bushel of the former, and one bushel of the latter, per acre. The ground is then rolled with a heavy stone or wooden roller, so as to be perfectly levelled. Care must be taken, however, to do this only when the land is thoroughly dry, as otherwise the seed adheres to the roller, making it necessary to sow a second time in autumn.

The construction of the small drainage channels is usually deferred until the sowing has been completed; and they are then made with ease, as their breadth does not exceed 9, and their depth 6 inches. It is usual to leave spaces at both ends of the meadow sufficiently large for

* Italian rye-grass.

carts to pass. These are indicated in the diagram by dotted lines; and the irrigation and drainage waters are carried across them by small wooden funnels. Irrigation is given to the new meadow in June, July, and August; and on first admitting the water, great attention is paid to removing all obstacles to its free circulation over the surface.

In illustration of the expense of forming winter meadows, the following details are given :—

The superficial area was 5 acres—the land had been previously under crop—was moderately level, and easy to work.

15th Nov.—	1st Ploughing,	£1	12	6
25th Jan.—	2d do.,	1	12	6
	Harrowing,	0	5	0
4th March—	3d Ploughing,	1	12	6
	Harrowing,	0	5	0
2d April —	Excavation of minor irrigating channels,	3	16	6
	Levelling the planes,	2	12	6
	Digging,	0	4	6
	Use of the *raggia*, or earth-scoop,	0	8	6
	Final ploughing,	1	12	6
	Do. harrowing,	0	5	0
	Spreading manure,	0	4	6
	Sowing,	0	4	6
	Rolling,	0	4	0
	Main channels of irrigation and drainage,	1	17	6
	Total expense for 5 acres,	£16	17	6

The outlay in this instance was therefore £3, 7s. 6d. per acre; but the example is certainly below the average; for, as will be seen by reference to the details, the levelling operations were extremely trifling. While there are extreme cases which rise far above it, I believe that an average of about £6 per acre will very fairly represent the ordinary cost of forming a winter meadow.

As land under *marcite* may be said to be in a constant state of production, it is of necessity very richly manured. The materials required are supplied in abundance by those vast dairies which are maintained throughout the

whole of the irrigated districts of Northern Italy; and I may give here a condensed abstract of the observations of Signor Berra on this branch of the subject. Foremost among the manures for *marcite*, he places the refuse of those large pig-sties which are attached to every farm, and in which the otherwise useless products of the dairy are consumed. So important is this manure considered, that farmers who do not themselves manufacture cheese or butter, always make it a condition with the parties to whom they dispose of the produce of their cows, that a certain number of pigs shall be maintained on the farm. It is usually calculated that three pigs supply, in the course of the year, manure sufficient for one acre of marcite. The manure is given in the liquid form, and is distributed awkwardly enough from casks on low carts which traverse the field. The arrangements for storing the manure are very inefficient, as it is exposed in open tanks, and great wastage is incurred. Sometimes, though but rarely, it is kept in covered masonry cisterns. It may be applied at any season of the year, care only being taken to give it immediately after cutting, as it injures the grown grass.

The stable manure, both solid and liquid, is usually mixed with earth before being applied to the field. In a corner of each *marcite* meadow is to be seen an oblong mass, which is formed of the clearances of the irrigating and drainage channels, the fresh earth removed from the surface of the land, and the manure from the horses and cows in the stables. These are all formed into a compost, which is applied to the *marcite* in the proportion of about 250 cwt. per acre during the year. Linseed oil-cake reduced to powder, and mixed with lime in the proportion of seven of the former to one of the latter material, is a very common manure for winter-meadows. About 15

cwt. of this compost is considered sufficient for an acre, and the mixture of its constituents should be made at least ten days before it is applied to the land. When so applied in autumn, some time should be allowed to elapse before water is admitted. In the vicinity of Milan, the refuse of soap-works, and like manufactories, is largely employed as a manure, and is highly valued by the cultivators in this locality, the effect being great, owing to the salts of soda and potash which it contains. One of the richest manures available is the matter which collects within the irrigating and drainage channels themselves, more especially in the vicinity of large towns, where the sewerage waters are made use of. I have already mentioned, that at Milan this is greedily sought, and it is found to stimulate exceedingly the productive power of the soil. The value of this material operates prejudicially in one respect, by leading to an excessive enlargement of the channels after each clearance. It is calculated that, in the province of Lodi, nearly one acre in every hundred of the irrigable land is thus rendered useless, which in a great area becomes a matter of serious consideration, amounting as it does in this single province to more than 1500 acres.

The quantity of water required for *marcite* is enormous. From the statistics given in Part II., it appears that one cubic foot of water per second is sufficient for the irrigation of about $3\frac{1}{2}$ acres only. On this point I was favoured with a memorandum by Signor Brioschi, a Milanese engineer of high reputation, of which I give a translation here, reducing the local to English measures.

"While it is impossible," M. Brioschi remarks, "to establish *marcite* without having a great deal more water than is necessary for the irrigation of the land, it is somewhat difficult to determine the precise quantity, as this

must vary with local circumstances. However, I will assume that the area of a winter meadow is 7 acres. The quantity of water which I conceive to be necessary for the perfect irrigation of this surface is 6 cubic feet per second, of which $4\frac{1}{2}$ become available for further use in the form of *colatori*, or surplus waters. The estimate therefore would stand thus :—

	Cubic feet per second.
Original irrigation of 7 acres, ...	6
Surplus after irrigation, ...	$4\frac{1}{2}$
Quantity of water absorbed, ...	$1\frac{1}{2}$

"The quantity actually consumed by an acre of *marcite* amounts, accordingly, to $\frac{1.5}{7} = 0.2$ of a cubic foot nearly, and the total quantity of 6 cubic feet, if thoroughly economised, would be sufficient, in actual practice, for the irrigation of from 15 to 18 acres, being from $2\frac{1}{2}$ to 3 acres per cubic foot." This result corresponds very nearly with that shown in the general statistics of winter irrigation formerly referred to. The average charge for 1 cubic foot of continued discharge during the winter months is very nearly £3. Hence the expense of water in *marcite* may be estimated at about 20s. per acre, under average circumstances.

Colombani* states that, in localities where the surplus waters are *lost*, it requires very nearly 1 cubic foot of water in continued discharge for each acre of *marcite*—an estimate which confirms that of Brioschi. It thence appears, that over this area there passes in twenty-four hours the enormous mass of 86,400 cubic feet, or nearly 390 tons, or 14,400 gallons of water!

As regards the produce of *marcite*, the following particulars may be interesting. They are given as the results of

* *Idrodinamica*, p. 136.

careful measurements and observations, made personally by Signor Berra on his own property, and with land of average quality, but possessing no special advantages, such as vicinity to large cities, or command of sewerage waters. The yield per acre is given as follows :—

	Cwt.
1st, Cutting in February, ...	84
2d, From March to April, ...	126
3d, From April to May, ...	131.25
4th, From May to beginning of July, . . .	73.5
5th, From July to middle of September, . . .	63
Total per acre during the year, ...	477.75

or very nearly 24 tons of grass. The *marcite* meadows in the vicinity of Milan, however, give fully twice this quantity, being cut in November, January, March, and April, for stable-feedings ; and in June, July, and August, they furnish three crops of hay, while in September they afford an abundant pasturage to the cattle. They thus give seven crops during the year, and the ordinary yield per acre is estimated at from 45 to 50 tons, with half as much more in remarkable instances.

Of the ordinary *marcite* meadows it is considered that 35 acres supply grass and hay sufficient for the maintenance during the year of 50 cows stall-fed, except in September and October, when they are turned out for pasture. Twenty acres are sufficient for the supply of grass during seven months, and 15 more furnish the hay required during the three winter months. To give an idea of the money-returns, we assume that the proprietor of fifty cows has 20 acres under *marcite*, the expenses and returns connected with which are as follows :—

EXPENSES.

Preparation of the land, repairs of irrigation channels, &c., for 20 acres,	£6 3 6	
Manure, 259 cwt. per acre,	63 5 7	
Labour in spreading and carrying do.,	2 7 0	
Labour in cutting during seven months, carriage of grass, &c.,	19 13 9	
		£91 9 10

RETURNS.

Food for 50 cattle in February, for fifteen days, at 3d. per head (being the price paid by proprietors of cattle, not farmers),	£9 7 6	
Do. from March to middle of September, for 195 days, at 6d. per head,	243 15 0	
Pasturage at 8s. 9d. per acre,	8 15 0	
Value of manure,	52 12 0	
	£314 9 6	
Deduct expenses,	91 9 10	
Total for 20 acres,	£222 19 8	

Or £11, 2s. 6d. per acre.

The proprietor of the land has been supposed in these estimates to be also the proprietor of the water; but should he not be so, the net returns would be decreased by 20s. per acre as the price of irrigation.

The produce of the plantations invariably surrounding irrigated lands is valued at £1, 6s. per acre annually. Hence the entire returns would amount, in case of the water belonging to the proprietor, to £12, 8s. 6d., and otherwise to £11, 8s. 6d. per acre. It is usually calculated that the net returns are divided equally between the landlord and the tenant. The rent from such land as the above would therefore be from £5 to £6 per acre.

When cattle are not fed on the farm, but the produce is disposed of either as grass or made into hay, the net returns range from £7 to £8, 10s. per acre.

In the vicinity of Milan the returns are very much higher, not merely because of the greater produce, but of

the better prices the demand of the city insures. It is not unusual to find the *marcite* here yielding a rent equal to the highest net returns elsewhere, the tenants paying from £10 to £12 per acre, and occasionally, under circumstances peculiarly advantageous, even double these sums.

These details regarding a cultivation so peculiar as that of *marcite* meadows, will not, I trust, be altogether uninteresting. Owing to the immense consumption of water it requires, it can be employed profitably only in countries where there is no demand for irrigation of any other kind during the winter months. This, as I have already shown, is far from being the case in India; but as there may be special circumstances which might admit of the system being employed—as perhaps in the valleys of mountain streams, or in localities where water is now running to waste, as in mill-streams, &c.—I have thought I might with propriety enter into the particulars now given.

SECTION III.

RICE-CULTIVATION IN THE IRRIGATED DISTRICTS.

As an important and familiar element of the Irrigation System of India, the cultivation of rice naturally interested me; and while in Northern Italy, I endeavoured to collect such information regarding it as seemed likely to be useful. This I propose to give in the present section.

The rice-cultivation of Piedmont and Lombardy is divided into two classes—permanent (locally termed *risaje da zappa*, from the use of the spade in its tillage)

and temporary (*risaje da vicenda*), which forms a part of the rotation of crops in the irrigated districts.

The permanent rice-cultivation is restricted exclusively to low marshy localities, unsuited for any other culture. It abounds in the swampy districts of Mantua and Verona; and though inferior in quantity and quality of produce to the other kind, it is still of great value, as being the only crop which soils so wet are capable of affording. When rice is introduced into the rotation, this extends over nine years, generally in the following order:—1st year, wheat, with grass seeds; 2d, 3d, 4th, meadows; 5th, 6th, and 7th, rice; 8th and 9th, Indian corn, or other crops, varying from year to year.

A clayey impervious soil, with a small proportion of sand near the surface, is found to be the best for rice. As the plant passes its existence in water, the details of the culture are directed to securing this condition. The means employed are much the same in Italy as in India. The surface of rice-land is made, as nearly as possible, horizontal; and where variations of level occur, a series of terraces is formed, each of which is carefully levelled. Compartments are then marked out, of which the dimensions are extremely variable, and each is surrounded by earthen walls or banks, about 2 feet high. Connection is established between the compartments at high and low levels, so that the water entering the first passes on to the others, and thus maintains a very gentle movement, which keeps the supply always fresh. It is an open question among Italian cultivators as to whether large or small compartments are best. With equal heights of water in each, many think superficial area a point of little practical importance; but in the best rice-provinces, as in Novara and Mortara in Piedmont, and in the Milanese, a preference is given to the system of small

divisions, containing each from 3 to 6 acres. Within such limits there is much greater facility in managing the irrigation, which is frequently, and especially when the crop is threatened with injury from blight or insects, a matter of great delicacy. The green rice-crop is peculiarly subject to the attacks of insects of different kinds, and it is solely by the management of the water that these are destroyed. If the animals are aquatic, the rice-field is laid dry for a time, and if otherwise, it is flooded; the much-dreaded enemies being thereby disposed of, whether they proceed from the land or the water.

When the divisions are duly formed, the rice-ground is ploughed and carefully weeded in spring. If the soil be too wet for the use of the plough, as in marshy localities, it is broken up by the spade, a tedious and unhealthy process. After the ground has been thus prepared, water is admitted for the purpose of verifying the levels, and of consolidating the partition-walls of the different divisions. It is necessary to remove all trees from the immediate vicinity, as shade is very hurtful to the crop.

The period of sowing extends from the beginning of March to the beginning of May. The new rice-lands are sown first, those which have been established for one or more years at a later period, as the soil is benefited by exposure for some time to the heat of the sun. Rice in the husk (locally termed *risone*) is employed as seed, in the proportion of from 3 to 4 bushels per acre, according to the nature of the soil. It is sown by hand; and as the land is literally in the state of mud, it is very laborious and very unhealthy work for the cultivator. It is necessary not to sow thick; and in proportion as the land is strong, the quantity of seed is diminished. It is usual to soak the rice-seed in water for twenty-four hours previous

to sowing, with the double object of quickening its vegetation, and preventing it floating on the surface of the water, as without this precaution it occasionally does. If new rice is employed as seed, it requires to be sown early, that is, in the course of the month of March; old grain is sown later—in April, or at the beginning of May.

Twelve or fifteen days after sowing, the young plants rise above the surface of the soil, and, as they increase in height, the sheet of water is gradually increased with them, so that merely their tops show above it. The fields are kept in this flooded state until the plant flowers, which, according to the time of sowing, takes place between the middle of July and the middle of August. About this time the flooding of the crop is replaced by regular but abundant irrigation, at intervals of a few days. When the head becomes well formed, the grain of good size, and the colour changes from deep to lighter yellowish green, all use of water is discontinued, the land is drained as dry as practicable, and in ten or fifteen days afterwards the crop is ready for cutting. The rice harvest in the north of Italy ranges, according to circumstances, from the middle of September to the beginning of October; and the crop is cut with the scythe when large compartments are used, and with the reaping-hook in the smaller ones. The grain is made into small sheaves about 25 or 30 lb. in weight, and with a constant length of 18 inches. When the plants are longer than this, they are cut higher, and the stubble is afterwards ploughed in as manure. The thrashing is effected after the Oriental fashion, by the treading of bullocks or horses; and the grain is subsequently dried for some days by exposure to the sun. It is then stored, and during the winter, when water is cheap and abundant, it

is cleared of the husks in the rice-mills attached to the farms, which are worked by water-power.

The produce of rice-land necessarily varies much according to soil and supply of water. The permanent rice-lands receiving but little manure, and being in low, marshy localities, difficult to cultivate efficiently, yield much less than those introduced into the usual agricultural rotation. In the provinces of Mantua, Verona, and Novara, where permanent rice-lands are extensive, the average produce per acre is estimated at from 30 to 35 bushels of uncleaned grain, or *risone;* while the temporary land in the same and the adjoining provinces yield about one-fifth more, or about 40 bushels per acre. Of the latter class, however, there are many which yield much more—even to 60 or 70 bushels. The process of cleaning reduces the rice to about one-third of its bulk; so that for permanent land the produce would be nearly 13 bushels. As an illustration of the produce of rotation rice-lands, I give the following, to which my attention was directed by a skilful Lombard proprietor of much experience in this cultivation. It is given in vol. ii. of the work entitled *Milano e il suo Territorio*, p. 140, and exhibits actual results, which I have reduced to their equivalents in English measure :—

STATEMENT showing the PRODUCE per Acre of ROTATION RICE-LAND in LOMBARDY.

	Uncleaned rice. Bushels.	Cleaned rice. Bushels.
1st Year, . . .	57.7	17.6
2d do. . . .	49.6	16.8
3d do. . . .	54.4	20.2
4th do. . . .	44.5	16.6
Totals,	206.2	71.2
Annual means,	51.55	17.8

The larger produce of the first year is due to the land

being new ; that of the third year is the result of thorough manuring. By the fourth year the land shows signs of exhaustion, no manure having then been given. It will be noted that, as the rice-land becomes older, the proportion of cleaned to uncleaned rice increases ; or, in other words, the grain is more easily separated from the husk in the latter years of the rotation. The cleaned rice may be valued at 6s. the bushel. Hence the gross average return per acre is £5, 6s. 9d. The expenses of cultivation were only about 15s. per acre,* and supposing the expense of water to double this amount, we have a net return of £4, 11s. 9d. per acre. It is mentioned that in certain years this same land has yielded 25 bushels of cleaned rice, thus giving a net return of £7, 5s. per acre. With a species of cultivation so cheap and so profitable, it is not wonderful that all attempts to restrict its extension should have failed. No sanitary regulations have yet offered more than merely temporary impediments to its progress. It has extended, and is extending even now ; and though the impression of its unhealthiness is universal, the temptation of its profits is too great to be resisted. I shall have occasion to show hereafter what has been done to reconcile sanitary and pecuniary interests—not, I would hope, necessarily incompatible in this case ; to do so at present would lead me away from my subject.

It is peculiarly difficult to form any precise estimate of the quantity of water necessary for a given area of rice-land. Unlike all other irrigated products which require only occasional watering, at more or less distant intervals, rice is flooded continuously for at least three months of its growth. The fields are then a series of ponds, so to

* So in the original authority; but I think the amount must be underestimated.

speak, receiving constantly such new supplies as are necessary to compensate for wastage by evaporation, absorption, and other causes. In such a system it is evident how great the influence of soil must necessarily be—it is, in fact, the most important consideration of all, and with its variations, vary also the quantities of water required. According to the best Italian authorities, 1 cubic foot per second is sufficient for the irrigation of from 35 to 40 acres of rice, being from 45 to 50 cubic inches per acre. This is fully twice the quantity required for ordinary meadow irrigation. In the Milanese it is held that land under rice absorbs every 24 hours a stratum of water having a depth of .47 inches, or very nearly half an inch. In Verona and Mantua, the daily consumption is estimated at just double this quantity. In the south of France, where winds, similar to the regular hot winds of the Indian summer, prevail, the depth of water to be supplied daily to rice-ground is estimated at .663 inches. It is calculated that, in the north of Italy and centre of France, the daily evaporation varies between 0.78 and .117 inches; while in the south, and under the influence of the hot winds, it increases to between .156 and .195 inches. Assuming the average daily loss by evaporation to be .180, we have for supplying the plants, and for loss by filtration, a stratum having a depth of .473 inches, which, from all the testimony I have been able to collect, is practically abundant. From these data it may therefore be safely concluded that a continued discharge of from 45 to 50 cubic inches of water per second is sufficient for the irrigation, throughout the season, of 1 acre of rice-land, supplying, as this volume would do, a daily stratum having a depth of between 0.62 and 0.68 inches.

In estimating the cost of irrigation for rice-land, I find it stated, that water to be so employed is sold throughout

the greater part of Lombardy at an annual rate equivalent in English money to £26 per cubic foot per second. Supposing this volume to be sufficient for the irrigation of 40 acres, we have a rate of 14s. 6d. per acre for water in rice-cultivation.

I have little more to add on the subject of the employment of water in agriculture throughout Northern Italy. The meadow and the rice lands may be said almost to divide between them that vast volume of water which is every year poured over the face of the country. The irrigation of Indian corn or flax consumes but a comparatively small portion of the supply, and I have not considered it necessary to advert to it in any detail. I conclude this section with a tabular statement of some statistical details, which may be useful for reference.

NUMERICAL DETAILS connected with the EMPLOYMENT of WATER for IRRIGATION in the AGRICULTURE of NORTHERN ITALY.

	Number of acres irrigated by 1 cubic foot per second	Number of waterings		Depths of strata of water			Price of irrigation per acre	Produce in grass or grain per acre	Net value of produce per acre
		During the month	During the season	Each watering	Monthly	For the season			
SUMMER—				inches	inches	inches	s d	cwt	
Meadows, . .	90	3	18	2.34	7.02	42.12	5 9	224	£3, 10s. to £4
WINTER—									
Meadows, . .	3	30	150	7.92	237.6	1188	21 0	450	£7 to £12
								bushels	
Rice, ...	40	..	100	0.62	..	62	14 6	17.8	£5 to £7
Indian corn, Flax, &c.	180	1	6	3.93	3.93	23.58	3 6	50	£2 to £3

SECTION LAST.

ON THE USE OF "FONTANILI," OR SPRINGS FOR IRRIGATION.

I have had occasion to refer frequently to the use of natural springs for agricultural irrigation in Italy, and it seems to me that I may appropriately finish the present chapter, by giving some more special account of these valuable sources of supply, and of the methods by which their waters are made available for useful purposes.

Throughout the whole of the great plain on the left of the Po, forming the irrigated region of Piedmont and Lombardy, there occur water-bearing strata of sand or gravel at depths which vary materially. In a zone about three miles in width, following generally the parallel of 45° 28′, and extending from the river Sesia to the Oglio, there is a very remarkable abundance of subterranean waters met with, at depths varying from 9 to 15 feet. The influence of the canals of irrigation on the level of such springs is very perceptible—as in the vicinity of the canal Martesana, and also near Milan, where the depth of the water-bearing stratum does not exceed 4 feet. The springs, however, most in request for irrigation, rise from greater depths, and are connected with the permeable alluvial beds which stretch away towards the rising lands on the northward of the plain. In seeking for these springs, there are a number of natural signs which are followed as guides; and though the faith in the magic virtues of the divining-rod, which once prevailed universally throughout these districts, may now have passed away, the fountain-seeker—a much-employed mem-

ber of the community—has still his traditional signs, which gather round the source he is in search of. Where, in the spring-time, the verdure of a meadow is of a deeper green than the general mass, or the soil of a field has a darker or damper appearance than the rest, there he considers it desirable to try his fortune. When, in the summer, the gnats are seen hovering in masses over a particular spot, and resting very close to the soil, he suspects that aqueous vapour is ascending from below, and that a spring must be near the surface. At all seasons of the year, light vapours frequently rest over the hidden springs at night and morning, and to these the searcher gives attention with the sort of practical instinct in recognising their indications which long observation creates.

Supposing that by these or other similar signs the existence of springs is sufficiently indicated, excavations are made through the surface-soil to those beds of sand or gravel which form the subsoil of the whole irrigated plain; and as new threads of water, rising to the surface, continue to show themselves, so does the excavation extend, until a supply adequate to the demand has been obtained, or until the area of the head of the spring reaches the limit beyond which it cannot profitably be carried, owing to the value of the land. The small jets of water forming the springs rise, of course, in variable volume, and with variable force; and in the large spring-heads (locally termed *teste dei fontane*), it is only the more important of these that receive special attention.

In the irrigated plains of Piedmont and Lombardy, the depth to which the excavation for springs has to be carried very rarely exceeds 8 or 9 feet; and owing to the natural slope of the country from north to south, this depth is soon worked out, and the channel brought to the level of the soil. The shape of the spring-head is deter-

mined entirely by the manner in which the jets (termed, on the spot, the *occhi*, or eyes of the spring) are distributed. Among the immense number I saw, there were none that affected any regularity of form, though the banks were trimmed and cared for with more or less attention, according to the tastes or habits of the proprietors. I observed generally that those in the Milanese were kept in better condition than either in Piedmont or the other provinces of Lombardy.

Passing through sandy strata, the jets are liable to obstruction from the matter the water carries with it, or from collections of earthy or vegetable deposits in the head. It is therefore necessary to protect them from these, and this is done by enclosing each jet within a wooden tube of variable depth, but generally ranging between 6 and 10 feet. This tube, of about 3 or 4 feet in diameter, slightly conical in form, is made of alder-wood or oak, about 1 or 1½ inches in thickness, bound with three or four strong iron hoops. It is, in short, very like a cask without a bottom, and it is forced into the soil until its upper rim is a few inches above the surface of the water in the spring-head. On one side of the rim a small cut is made, through which the discharge of the water takes place, and occasionally, though rarely, the top is covered over.

The excavation of the flooring of the spring-head is carried to a depth of about 1 foot or 18 inches below the level at which the jets are distinctly visible. The sides are either formed in long slopes and sown with grass, or, as in many instances I saw near Milan, neatly revetted with small piles and planks, and having trees planted all round, so that the spring-heads are generally rather picturesque spots. Occasionally it happens that the entire basin becomes filled with water, in such manner as to

make it difficult to discover the localities of the jets. My kind friend, M. Charles Noe, drew my attention to an example of this kind in the Vercellese, and informed me that the method usually employed to discover the jets was to leave the water undisturbed for some time, when the surface became covered with water-cresses, which were invariably much denser over the sites of the jets than anywhere else. I saw this very distinctly in the case in question, and the indication is considered on the spot an almost infallible one.

When the dimensions of the head and the consequent volume of water have been tolerably well ascertained, the next process is to excavate the channel of irrigation (locally termed *asta di fontana*). Regarding this there is nothing special to remark, as it is merely an ordinary channel, having dimensions and slopes varying according to local circumstances. When the soil is very porous, wooden or metal pipes are occasionally in use to economise the water, though it is but rarely that such expedients have to be employed.

As all springs become the private property of the parties on whose lands they are found, their value may be ascertained by a comparison with the sums paid for like quantities of water derived from the ordinary canals of irrigation. We have formerly seen that a volume equal to 1 cubic foot per second may be purchased in perpetuity for about £280. The discovery of a spring giving from 5 to 10 cubic feet, which are the ordinary limits, increases the value of the property on which it is found by from £1400 to £2800 ; and as the expenses scarcely equal, in average cases, a hundredth part of these sums, it is easy to understand the extent to which the system has been carried, and the importance attached to it, especially as the command of spring-

water is so valuable in the establishment of *marcite* meadows.

The great and the minor canals of Northern Italy derive occasionally no inconsiderable portion of their supplies from the subterranean waters. The depth at which their beds are usually placed beneath the surface of the soil brings them within the limits of the water-bearing strata, and on all occasions, when the main supply from the rivers is cut off, the effect of the springs is very perceptible. It is, indeed, generally held that the proportion due to these is equal to from one-fifth to as much as one-third of the total volume. The Naviglio Taverna, of which the entire discharge is nearly 30 cubic feet per second, draws only 15 of these from the canal Martesana, the remaining half being from springs opened during the progress of the excavation for the bed. In this case the capital value of the additional supply of water thus obtained does not fall below £4200, and similarly with the private canals Litta, Cattaneo, Visconti, Barmetti, Borromeo, and, in fact, nearly the whole which form the branches of the great arterial lines.

It would be vain to attempt to give any rigid estimate of the total quantity of water supplied by springs for agricultural purposes, as no perfectly trustworthy data exist on which to base it. I will therefore merely mention here, that in the *Notizie Civile e Naturale su la Lombardia*, Lombardini calculates the total quantity utilised in the Lombardian provinces at 2160 cubic feet per second, and that Michela, in the notes attached to his history of the canal of Caluso, estimates the volume for the Lumellina alone at 788 cubic feet per second. We shall certainly be under the truth if we estimate the whole throughout the irrigated plain of Northern Italy at 3000 cubic feet per second, of which the value in money is not less than £840,000 sterling.

With these details I terminate the Third Part of this Report. My object has been, not so much to enter into very minute particulars on the practice of irrigation, as to give a general idea of its most note-worthy features. The Irrigation System of Northern Italy demands, as essential to its existence, the possession of large capital and the concentration of property in the hands of wealthy proprietors. To this combination its actual development is due; and however well the system of small farms may act in Upper Lombardy, I believe it would be the entire ruin of those provinces whose fertility has been produced entirely by their canals of irrigation, constructed at vast original outlay, and maintained at present by heavy and annually recurring expenses, beyond the means of small proprietors to defray. To establish, in well-adjusted proportions, the various kinds of irrigated culture I have adverted to, and to insure an adequate return on the capital thus invested, requires farms of large areas, and working capital of considerable amount. In a calculation I have now before me, it appears that, to work efficiently an irrigated farm of 640 acres, would require, on the part of the tenant, command of capital to the extent of at least £6000, while the amount sunk by the landlord in constructing canals, farm-buildings, and in levelling operations necessary to adapt the land for irrigation, is estimated at £40,000. Unless such sums are at the command of the one party, and have been invested by the other, the maximum advantages of irrigation are not to be obtained, as the water has not full justice done to its capabilities. It is clear therefore, that, for Lower Lombardy, the existing arrangement of large farms, held by superior tenants under liberal landlords, is not only the best, but I believe the only system adapted to a region whose agriculture is based on irrigation, and where

the Government does not assist in the construction of works of distribution. If measures be taken to alter the distribution of property—to replace the large by small proprietors, I feel quite certain that the descent of Lower Lombardy, from its high position among the productive regions of Europe, will be rapid and inevitable. These remarks do not apply at all to Middle and Upper Lombardy, where irrigation enters but little, if at all, into the system of husbandry. There, subdivision of property has not yet, so far as my observation went, been productive of any injurious effects whatever; but I must repeat, that circumstances are wholly different in provinces whose agricultural life's-blood, so to speak, circulates in their irrigation channels. Even now, the financial pressure checks the essential freedom of this circulation; and if it is carried so far as to lead to permanent embarrassment on the part of existing proprietors, and the necessary partition of land to meet demands so oppressive, the Government will most unquestionably soon have cause to feel that they have realised the ancient fable, in killing the bird that for so many centuries has been laying eggs of gold for their use.

PART IV.

LEGISLATION OF IRRIGATION IN NORTHERN ITALY.

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INTRODUCTORY REMARKS, BEING A HISTORICAL SUMMARY OF THE PROGRESS OF THE LEGISLATION OF IRRIGATION IN NORTHERN ITALY.

THERE is reason to believe that long before the laws affecting irrigation in Northern Italy were embodied in any written code, they were recognised and acted on as being among the common customs or unwritten laws of the country. The earliest record of them which now exists is found in a manuscript collection of the statutes of Milan, preserved in the great Ambrosian Library of that city, and bearing date 1216. But in this collection they appear not as new laws then for the first time established by the local government, but as customs which from time immemorial had regulated the matters to which they specially apply. Verri, who is considered one of the most careful of the historians of Milan, is disposed to carry back the date of the first compilation of the statutes to the tenth century, when Otho the Great, emperor of Germany, granted to the cities of Lombardy the right "to live according to their ancient laws and local customs," a

right subsequently ratified and confirmed by Frederic I. at the peace of Constance in 1183. In the historical summary I have formerly given of the progress of irrigation, I have mentioned that this was the period when the greatest of existing canals were executed; that it was, in truth, the birth-time of that irrigation system to which Lombardy owes its singular agricultural prosperity. But the use of water on a smaller scale was traced to a much earlier period, and reaches back even to classic times. The unwritten laws of irrigation in this region are therefore considered, with probability, to be fragments of the Roman jurisprudence once established there, and which have survived the destructive influences of that dark period which intervened between the fall of the Empire and the rise of modern civilisation, by right of their utility and adaptation to the wants and habits of the people.

In the code of 1216, formed by Brunasio Porcha of Novara, then Podesta, or elected chief of the republic of Milan, we find embodied the leading ideas which at the present time regulate the legislation of irrigation. Without entering into minute details, it will, I am sure, be interesting to quote those provisions which, for at least seven centuries, have influenced the social state of Northern Italy, and whose beneficial effects are to be recognised over the whole region of irrigation.

The ancient laws regulating the use of water are found in Statutes 240 to 249, and in general terms are as follow:—

"1. Whoever has the right to obtain water from springs or rivers, or in any other manner whatsoever, can carry it through the fields and farms of any individual, commune, or public corporation in this state, and also across the public roads.

"2. To this end he can construct the canals or channels,

and other necessary works, at the least possible inconvenience and injury to the proprietors of the farms, paying one-fourth more than the true value of the land thereby occupied.

"3. In addition, he must repair all damages caused by the works, according to the estimate of two practical men (*periti*)—provided, however, that the compensation for damages shall in no case exceed twice the value of the property damaged.

"4. He shall be bound to maintain in efficient repair, at his own expense, the bridges and drains required for the passage of the water, whether on the farms or across the roads, so that these latter shall suffer no injury, especially in rainy weather.

"5. The water may be conducted, or caused to pass, above or below canals previously existing, new channels of brick and lime being made for it in such manner as that the water flowing under shall not be mixed with that flowing over or within the pre-existing canals.

"6. These new channels must be maintained in such condition as that the proprietor of the water at the upper levels shall suffer no damage from the reflux of the same. The water shall have a free and unobstructed course."

Such were the earliest provisions made in the interest of irrigation. They express very clearly that right of passage which, as securing the free circulation of the water without let or hindrance from the passions or ignorance of individuals, lies at the root of a widely-spread system of irrigation; while, at the same time, precautions are taken to make the exercise of this right, so essential to the common good, as little oppressive to individuals as is compatible with its full enjoyment. The limitation of the right, by the condition that it shall be exercised only in the way which, according to professional judgment, is

least injurious to the party granting the passage, has been found to operate most beneficially in practice; and so universal is the conviction of the necessity for the maintenance of the right thus guarded from abuse, that opposition to it is almost unknown. However much the experience of centuries may have amplified the laws of irrigation, it is to this first rough code that we have to trace the establishment of the leading principles which have regulated the gradual development of the system.

These principles are briefly—

1st, The right of passage.

2d, The limitation of this right to lines of least inconvenience.

3d, Payment for the land occupied, with a certain fraction in excess of the true value—being one-fourth in this case.

4th, Compensation for damages—limited here to not more than twice the true value of the damaged property.

5th, Obligation on the proprietor of the water to maintain the works.

6th, Obligation on the proprietor of the land to keep the channel free of impediments to the course of the water.

The old Statutes further contain a number of detailed regulations connected with irrigation, such as limiting the distances of canals or springs from each other, or from rivers the property of the State; securing certain distances on each side of the channels for the reception of the deposits cleared from them; prohibiting the construction of dams in rivers without due authority—and so on. But the preceding abstract will give a sufficiently clear idea of the general principles involved, to make it unnecessary for me to dwell longer upon them.

From time to time, during the middle ages, new collections of the Statutes were formed by different princes. In 1351, Luchino Visconti caused the whole to be revised;

and his successor, the great Giovanni Galeazzo, published the collection in 1396, under the name of the *Nuove Constituzioni.* In 1457, the right of passage was specially established by Francesco Sforza on the Canal Martesana; and some time afterwards, the reigning duchess of Milan, Bianca Maria Visconti, published a new series of regulations for its exercise, of which the most remarkable was, that the engineers to whom was committed the duty of determining the amounts of compensation to be paid were to be named in equal numbers by the proprietors of the water and the land—an arrangement difficult to work in practice, from there being no provision for a casting vote in the event of an equal division of opinion. After the termination of the national dynasty, on the defeat and capture of Ludovico Sforza il Moro, by Louis XII. of France, another series of statutes, carefully embodying all pre-existing laws of irrigation, with such farther developments as seemed expedient, was published in 1502 by the latter monarch.

About the same time the republic of Venice established, throughout its irrigated provinces, regulations similar in principle, though different in detail, to those of the Milanese. It may be curious to show how this question was treated by a body so celebrated as the senate of the republic; and I have therefore translated the following statute on irrigation, which bears date the 27th August 1455, and is therefore very nearly four hundred years old. It is applicable to the province of Verona, where, as formerly remarked, there are canals of irrigation very nearly as old as the Naviglio Grande, and where common custom had doubtless preserved, by equally clear tradition, traces of a legislation far more ancient than any written record. The Veronese statute is as follows :—

"1. Every inhabitant of the territory of Verona is at liberty to derive, from the rivers appertaining to the State, such supply of water as is necessary for the irrigation of his property, on obtaining the requisite authority from competent magistrates, and under the condition that he inflicts no injury on parties possessing older rights to the same waters.

"2. Whoever shall obtain the right of establishing an irrigation channel, may demand a passage for the water across the land of any other person; paying, however, to the proprietor, *twice* the value of the land occupied.

"3. This value shall be fixed by skilful men chosen by the parties interested.

"4. The compensation shall be payable in advance, except when the proprietor of the land is willing to grant a delay thereof.

"5. On fulfilment of the above conditions, the sale of the land demanded shall be obligatory, and should be effected by a legal act.

"6. In case of refusal on the part of the proprietor to acquiesce in the preceding terms, it shall be competent to the administrative authority (the Podesta) to adopt compulsory measures, since the right to the possession of the land exists without reference to the inclinations of individuals, corporations, or communities.

"7. Possession obtained in execution of the present statute shall be held good and admissible as regards the grantee.

"8. In the case of a proprietor refusing all acquiescence in the possession thus granted, and declining to receive the price of the land, regulated as above prescribed, this price shall then be deposited with the authorities; and immediately after this formality, the works of irrigation may be begun.

"9. When parties differ as to the proper position of the channel, the professional men, named at the instance of the recusant, ought always to prefer the place least injurious to the property traversed.

"10. The same rule ought equally to be observed in cases of dispute regarding channels sanctioned prior to the publication of this statute.

"11. When a channel intersects another canal, or water-course of any kind, the passage shall be effected either above or below, by means of appropriate works of art. The proprietor demanding the passage shall be bound to deposit security for all damages which may be caused by the said works to water-courses or canals previously in existence.

"12. This precaution being observed, the proprietor of the land cannot impede the execution of the works, but ought to lend all practicable assistance during the period of their construction. The definitive settlement of the amount of compensation for damages shall be made on the completion of the works.

"13. In the event of the construction of a water-course causing a marked diminution of the extent or value of a property, the party claiming the passage shall be bound, not only to pay compensation for all injuries as estimated by professional men, but also to purchase the entire property should its owner so desire.

"14. The present statute is applicable only to canals and water-courses to be constructed within the province of Verona."

This law exhibits the importance attached to irrigation, in leading the Venetian legislature to sanction, on its behalf, so decided an interference with the rights of property as is here exhibited, and in the scrupulous care

taken to make such interference productive of the least possible injury. The same general principles pervade the laws of Verona and Milan, but the former are more stringently protective to the proprietor of the land than the latter. The payment of twice the real value of the soil —the obligation to purchase the entire property, should it be seriously deteriorated—and the payment of all demands in advance, except those for damages, which could not then be known, are features peculiar to the Venetian legislation, and indicate an anxious desire to reconcile the rights of property with that free extension of irrigation which was so essential to the general agricultural interest of the province.

After the defeat of Francis I. at Pavia, and the subjection of Lombardy to Charles V., a new code of statutes was published by the latter in 1541. As the Sesia was then the boundary of the Italian provinces subject to Spain, these statutes were extended to the region between that river and the Ticino. But here, as in the ancient duchy of Milan, and the irrigable provinces of Venice, there is reason to believe that tradition had regulated the distribution of water for ages before the code of Charles V. was introduced. M. Giovanetti mentions, that, having had occasion to examine many documents of the tenth, eleventh, and twelfth centuries, he has found in these numerous proofs that in Novara the principles of the Roman law, in matters connected with the use of water, had never been wholly lost sight of, but, embodied in the traditions of the people, had continued, in unwritten forms, to influence the development of irrigation there. Before the time of Charles V., the canals of the Sesia, Busca, Biraga, Mora, and others, were in existence, meadow and rice cultivation was established, and the general machinery of an irrigation system was fairly at work. It is certain,

however, that the introduction of a legislation already so well defined as that of the Milanese, into the provinces west of the Ticino, was of the utmost value in stimulating agricultural improvement; for it is well known that, at the middle of the sixteenth century, when the statutes of Charles V. were made the laws of all his Italian provinces, the extent of irrigation in Novara was less than one-fifth of what it is at this moment.

However little Northern Italy may be indebted to the dominion of the Spaniards in other respects, it is undeniable that they devoted much attention to the development of irrigation, bringing with them, doubtless, the traditions of the Moors, to whom they owe their own remarkable system, which exhibits many features worthy of careful study.

As regards the other provinces of Piedmont, an imperfect legislation of irrigation was preserved in the ancient provincial statutes, or the immemorial customs of different localities. The right of passage is always recognised in the earliest statutes, though in these the party claiming it is bound to pay no more than the simple value of the soil occupied. The first notice of any legislation by the house of Savoy dates from 1584, when the right just referred to was distinctly established, with some slight modifications of the ancient conditions, by an edict of the Duke Charles Emanuel. This edict, however, was very vague and indefinite; and it is in the Royal Statutes of Victor Amadeo II., and in those of his son, Charles Emanuel III., published in 1770, that we find the legislation of Piedmont assuming a clear and definite form. To illustrate the first stages of legislation in Piedmont, as I have already done those in Milan and Verona, I give a translation of such parts of these statutes as apply specially to irrigation.

"1. Every commune, corporation, or individual whatsoever, shall be bound to grant a passage through their lands for waters legitimately derived from rivers or fountains, whether for irrigation or machinery. This passage shall likewise be granted through existing canals and water-courses, provided always that this operation shall cause no injury to the proprietors of these canals, and shall in no way impede the free course of their own proper waters.

"2. Whoever claims a passage for his water-course across the property of another ought to effect the same with the least possible injury. The proprietor of the water shall pay the value of the soil occupied, with one-eighth in excess, as estimated by professional men. He shall farther repair all damages he may cause, or pay the full value of the same.

"3. Whoever has the right of obtaining water, whether from rivers, streams, torrents, or from canals and water-courses, shall be bound to do so in such manner as to cause no injury, either to proprietors above or below, by the reflux or the stagnation of the waters. Whoever by their own neglect shall violate this provision, and thereby injure others, shall be liable, not only to repair the damages done, but also to pay a fine of ten crowns in addition.

"4. If the waters thus flowing for the benefit of individuals shall impede the free transit of proprietors from one point of their properties to another, those benefiting by the canals shall be bound to construct and maintain bridges wherever the necessity for cross-communication may exist, provided always that there shall be no agreement between the parties to the contrary."

Some characteristic differences will be noted in the terms of the foregoing regulations, as compared with those

of Lombardy. The compensation for the occupation of the soil is only one-eighth in excess of the true value. The proprietors of pre-existing canals are bound to permit the use of these for new supplies, unless they can prove that injury to their interests will be the consequence thereof; and the parties availing themselves of the right of passage, but neglecting the duties connected therewith, are subjected to punishment by fine, in addition to payment of the cost of damages due to their neglect. The right to make use of pre-existing canals, though it does not specifically appear in any of the written statutes of Lombardy which I have seen, was still practised there to a considerable extent, and from a very ancient date. It is supposed to have originated at the time of the construction of the Naviglio Grande, which in its course intersected several pre-existing channels. Hydraulic architecture was then in its infancy; the use of syphons, aqueducts, and similar works, was unknown for many years afterwards. The only way of preserving uninjured the interests of the proprietors of these old channels, was to allow the waters in them to enter the bed of the Great Canal, and to grant outlets discharging nominally equal volumes at such lower levels as were most convenient. There is no difficulty in understanding how easily this arrangement lent itself to abuse: the quantity of water entering the main canal from a pre-existing channel was never clearly known; and it was invariably found that the volume taken from it exceeded much its legitimate limits. So great and manifest became the losses due to this cause that means were found, in the invention of appropriate works, for carrying all waters above or below channels previously existing; and the obligation to do this became, as has already been shown, a prominent feature in Lombardian legislation, being one of the main causes of the

high cost of all canals of irrigation in this region. From time to time, however, even down to very recent date, the local government granted permission for the junction of waters belonging to different proprietors in the same channels; and as there are, unquestionably, circumstances under which it might be convenient to both parties to abide by such an arrangement, we shall hereafter see how the principle has been maintained, and at the same time guarded from abuse, in the modern systems of legislation. Its first appearance in that of Piedmont is found in the edict of Charles Emanuel; but it is there expressed in terms so absolute that its employment in practice must have led to much abuse and litigation.

During the reign of Maria Theresa, great improvements were effected in the administration of the canals of Lombardy, and many new rules were introduced by her local government, all tending to establish more clearly the ancient principles of legislation, and to facilitate their application in daily practice. Proprietors irrigating from the different canals and rivers were formed into associations, with power to elect representatives, to whom the internal management of the works was committed. Engineers were attached to each association, and over the whole a supreme council of irrigation was nominated, and charged with the general superintendence of all matters connected with the use and distribution of water throughout the kingdom. Such associations were of very ancient origin in Lombardy—some, as that of the river Olona, dating from the twelfth century; but all were reorganised at the time we are now referring to, invested with large powers, and brought into close relation with the public administration. The regulations thus established continued in force during the existence of the Cisalpine and Italian republics, for which a legislative council was organ-

ised about 1802. So many of the old feudal statutes were swept away during this convulsive period, that special legislation on the subject of irrigation became necessary, and on the 20th April 1804, a law was promulgated by which the Statutes of Milan and the Constitutions of Charles V. were re-established. On the 20th of May 1806, another law was published, amplifying the provisions of the preceding, and embracing not only irrigation, but its allied subjects of drainage and improvement of land.

In 1816, the Civil Code of Austria for the Lombardo-Venetian kingdom was published. In this, no special provision was made for securing that right of passage, hitherto a fundamental principle of the legislation of irrigation. In consequence of this omission, serious disputes arose; and the question having been finally carried before the Aulic Council of Vienna, a decree of this body, dated 17th August 1820, re-established in full force the laws of April 1804 and May 1806, by which, at this moment, all questions connected with the use of water for irrigation are regulated.

That portion of Piedmont which was incorporated with the kingdom of Italy benefited by the laws of 1804 and 1806, until the fall of Napoleon, when the Ticino became the boundary of the kingdom. In 1814, the royal statutes of Charles Emanuel were re-established for the entire monarchy; and three years afterwards a patent was published, in which the provisions of these statutes were clearly defined, amplified, and protected by various penal awards. With like objects, other royal patents were published in 1828, 1834, and 1836; but as all the details in these are reproduced more elaborately in the Civil Code of 1837, it is not necessary for me to dwell upon them now.

For Lombardy, therefore, the Civil Code of Austria, and the Laws of the 20th April 1804, and 20th of May 1806, form the existing legislation of irrigation. For Piedmont, this is embodied in the Civil Code of Charles Albert. I now proceed to give such portions of these various enactments as are immediately connected with my subject.*

* In the preparation of the preceding summary I have consulted a great many authorities, for access to which in original I am indebted to the liberality of the Court of Directors of the East India Company, by whom I was supplied with the means of procuring copies of the whole. As the same works furnish me with all my materials for the subsequent chapters on the Legislation of Irrigation, I quote those to which I have been most indebted below :—

"Statuti di Milano." 2 vols. of text, with notes, and an appendix of interesting observations. Milan : 1773.

"Codice Civile Universale Austriaco pel Regno Lombardo-Veneto. Edizione Ufficiale." Milan : 1815.

"Raccolta dei Leggi, Regolamenti e Discipline, dell' Acque e Strade del Regno d' Italia." 2 vols. Milan : 1806.

"Manuale delle Leggi, Regolamenti e Discipline, intorno alle Strade, Acque, &c., da Antonio Cantalupi." 4 vols. Milan : 1845.

"Codice Civile di Sardegna ; Codice Penale di Sardegna." 2 vols.

"Régime des Eaux par Jacques Giovanetti." 1 vol. Lithographed.

"Rapport sur la Pratique et la Legislation des Irrigations. Par M. de Mauny de Mornay." 1 vol. Paris : 1844.

"Des Canaux de l'Irrigation. Par M. Nadault de Buffon." Vol. iii. Paris : 1843.

"Manuale di Idrodinamica di F. Colombani ; Appendices on Legislation in Lombardy and Sardinia." Milan : 1845.

"Romagnosi, Trattato della Condotta della Acque." 4 vols.

CHAPTER I.

LEGISLATION OF IRRIGATION IN LOMBARDY.

SECTION I.

RIGHT OF PROPERTY IN WATER.

THE right of property in all running water, whether of rivers, streams, or torrents, appertains, in the Lombardo-Venetian kingdom, to the Government. The water of springs existing on the private properties of individuals is the only exception to this general rule. I cannot better illustrate the growth of the right of the Government, above referred to, than by the following short quotation from the work of M. Giovanetti, in which this accomplished lawyer traces it from the earliest times of which records remain :—

" It is to an object of the most important and most serious character that I now desire to draw your attention. Call to mind the remark I formerly made, that we in Northern Italy had been judicious in ranking among the things appertaining to the royal or public domain, the waters of all rivers and streams, whether navigable or non-navigable. In this respect, Art. 420 of our Civil Code is the reverse of Art. 538 of the Code Napoleon,

which regards navigable rivers only as those belonging exclusively to the State.

"The distinction between waters which are public property, and those which may be appropriated by individuals, has always appeared to me to merit the especial attention of the legislator.

"On this distinction is based the solution of a vast number of questions on the right of property in the bed, on the alluvial deposits, and on the waters themselves. But to explain clearly my views, it is necessary that I should trace briefly the history of the right. Be good enough to follow me. I will move rapidly; but, for love of order, I will divide the matter into several paragraphs.

"In my opinion, the Roman lawyers have viewed the relation of waters to the public interest in a very just manner. They have declared public the navigable rivers, and all those which could be rendered so; but in doing this, they propose no other end than to render more efficient the navigation and the ports. According to them, the use only of the bed was public, but the right of property to the bed, to the islands existing in it, to the alluvial deposits, and, in the event of a change of course, to the abandoned channel, was held to appertain to the proprietors on the banks. The fundamental principle from which this system flowed is recognisable at a glance. There was no necessity—there would, in truth, have been many inconveniences—in reserving to the public domain more than the simple use of the waters for navigation or transit in any other form. The establishment of a patrimony for the community was not the object to be contemplated, but simply to place beyond the reach of private appropriation all that naturally was designed for the common good—all that facilitated individual or commercial intercommunication; and hence stimulated social

development, and quickened the march of that progress to which the Creator has called us. But beyond these limits, it is palpably for the general good of society and progress that the fertile principle of private right should be left to the freest possible action.

"All that the Roman jurisprudence has established regarding the bed, whether occupied or abandoned, on alluvion and on islands, is no more than the logical sequence of the regulating principle which we have noted.

"The natural corollary of this system is, that a right to a supply of water from a river, a stream, or a torrent, may be acquired either by a direct grant, or by prescriptive title, on the distinct condition that no injury shall thereby be inflicted on the navigable efficiency of the waters, and that the public administration has the power of revoking any grant whatever, whether tacit or expressed, whenever it violates this condition.

"Such is the state of the question according to the Roman law, which has always been acknowledged with us, notwithstanding the feudal law, which especially affects the Lombard cities, and to which I have now more especially to refer.

"To complete, however, my explanation of the ideas of the Roman lawyers, I have to observe, that, in subordination to the interest of the entire community, there arises a second interest, less extended, it is true, but which unquestionably ranks among what are termed collective interests. It is for the protection of this secondary interest that every derivation of water from any river, whether navigable or otherwise, exists under the condition that it shall not be injurious to neighbouring properties. Hydraulic agriculture ought to learn to profit by this precious germ, due to the high intellect of the legislators of a great people, and to glean from it the means of guarding and

regulating those collective interests which develop themselves with the progress of irrigation, and with the growing importance which water, daily almost, gathers in those countries so fortunate as to be able to employ it usefully.

"The irruption of the barbarians brought into Northern Italy the Germanic rights and the feudal laws. All the rights appertaining to the public, centred in the feudal lord of a commune, a province, or a kingdom, becoming his absolute property. It appears to me that it was not for purposes of police that the feudal superiors exercised all the rights of masters over the various water-courses, but that their right of *absolute property* necessarily absorbed everything previously held to belong to the community. There existed, in fact, merely the relations of masters and subjects.

"At the peace of Constance, in 1183, the Italian towns of the Lombard League recovered all the rights previously vested in the feudal superiors, and from that time the rivers have been held to be public property. These rights were then vested in the cities themselves, which, as you know, exercised authority over a certain extent of the adjoining country. When the monarchic element was introduced, there were constant struggles between the royal and municipal governments on the question of the right to the running waters, and of the amount of tax to be paid for their use."

The results of these various struggles have tended to define clearly the different rights involved; and while the Government now disposes of the waters of all rivers and canals, it recognises the claims of towns, or communes, or associations of proprietors, to the supplies which they have enjoyed by grant or prescriptive title for long periods of time. It is to this arrangement that the exceedingly limited advantage derived by the State from the waters

of Lombardy is to be traced. In the historical sketch of the great canals, I have given numerous proofs of the extent to which private rights had grown up during the troubled times, and under the various dominions, native or foreign, which have prevailed in the country. The right asserted by the State is now an almost barren one, and its enforcement has reference rather to administrative and police duties than to *direct* financial considerations.

In exercising its right of property in waters available for irrigation, the government of Lombardy follows one of three courses. 1st, It disposes of the water in absolute property, to parties paying certain established sums for it. 2d, It grants a perpetual lease of the water on the payment of a certain annual amount. 3d, It grants a temporary lease for a variable time at a certain annual rate, the water reverting to the State on the termination of the lease. By far the most common of these courses is the first; and it has, on the whole, I think, operated beneficially in the actual circumstances of the country.

The great landed proprietors during the progressive development of irrigation were the municipal, the religious, and charitable corporations, and the powerful noble families, the feudal superiors of the soil. As the whole of these associations commanded large capital, it was in their power to pay at once the sums required by the State, for such volumes of water as were suited to the wants of their respective properties; and having thus secured the right to employ the waters so purchased as seemed to them best, they were relieved from all harassing interference in applying them for their own use, or in disposing of them to others. With the revival of knowledge in Italy, the art of hydraulic engineering was called into existence, and the extensive demand for skill in its details created early a supply of men familiar with all of

these. Hence the remarkable number and the great talent of the executive engineers, by whose exertions, rewarded and stimulated by their wealthy and powerful employers, that vast network of irrigation channels was spread over the entire face of the country. We have, in fact, seen repeatedly that the private resources thus employed were more powerful than those of the State itself; their proprietors carried on a successful resistance against every attempt of the administration to enforce the regulation of their water-courses, or the introduction of fixed measures for their supplies. Varied though the dynasties governing Lombardy have been, and however different in their origin, their claims, or their systems of administration, all found that, having once granted the absolute property in the waters of the country to private parties, in consideration of certain sums paid, or services rendered, they had thereby created collective interests powerful enough to maintain this right against all encroachment, and even to withstand, up to the present hour, the just claim of the State to regulate the grants according to their original terms. Whatever the actuating motives for their moderation may have been, there is certainly no just cause to consider the manner in which the governments of Lombardy have administered their rights to water as oppressive or despotic; in truth, it would perhaps have been occasionally better for all parties, had they been able to carry their administrative reforms farther; but, looking to the general result, it may safely be asserted that, in the peculiar circumstances of the country, with the wealth at the command of the landed proprietors, the number and the skill of its engineers and agriculturists, the disposal in perpetuity of the water has operated powerfully in producing that social prosperity for which the irrigated districts are so remarkable.

I have considered it necessary to qualify the preceding opinion by reference to the special circumstances of the country, since I am very far from thinking, that because, as a matter of fact, irrigated Lombardy has reached a highly productive state under the system of sale of water in perpetuity, it would therefore be wise to introduce such a system at once into other countries. In Northern India, for example, as in Lombardy, the Government possesses the right of property in all running waters whatsoever; it may equally dispose of them for ever if it thinks fit, and it has far greater power to secure the maintenance of such grants as it may make in all their original integrity. But this part of irrigated India wants two important elements of that success which marks the progress of irrigation in Northern Italy. It has no great landed proprietors, with the will and the means to undertake expensive works, for utilising the grants of water which might be made to them; and the science of hydraulic engineering is as yet virtually unknown in its social system. The Government must, in justice to itself, fix a fair value on the water; and I doubt very much whether, on its doing so, any private parties would be found willing to undertake the responsibility of constructing large hydraulic works for its distribution. The profession of an hydraulic engineer does not yet exist, and it will be called into being with better effect under a system less liable to abuse, and more easy to control, than that which the force of circumstances rather than deliberate choice has established in Lombardy. A grant in perpetuity of such a material as water, whose value must necessarily go on augmenting with the progress of agricultural irrigation, is an act of injustice towards the Government, and is especially so in a country where the revenue derived from the water forms a legitimate addi-

tion to the resources of the State, supplying it with the means of extending the works, which, in the actual condition of society, it alone is able to undertake. Hence, therefore, I am distinctly of opinion, that for the Government of India to follow the example of that of Lombardy, in parting for ever with its right of property in the waters of the country, on receipt of sums which cannot possibly represent the real value of the article, would be an unwise course, not only as regards its own interests, but also those of the irrigating community. For there is no one point better established by experience in Northern Italy generally, and in Lombardy particularly, than this, that the selfishness of grantees in perpetuity of water has been one of the most serious obstacles to the development of irrigation. Acting on the principle that they had a right to do what they liked with their own, they were in the habit of suspending arbitrarily the supplies of water disposed of by them to other parties under subordinate grants, of increasing as they thought fit the prices to be paid, and, in a word, of pushing to its utmost limits the right of absolute property purchased by them from the State. But an agriculture founded on artificial irrigation cannot advance as it ought to do, under such an arbitrary system; and so, in protection of the irrigating communities, there gradually grew up a right, which, being acknowledged by the legislative tribunals, modified the despotism of the government grantees. This right bears the name of the *diritto d' insistenza*, and assures to a province, or commune, or association of irrigators, or even to individuals, a legal claim to a continuance of such a supply of water as they may have enjoyed for long periods of time, and on the faith of possessing which they may have incurred heavy expenses. So long as the irrigating community pays the water-rent fixed by the grantee of the canal, it cannot

be arbitrarily dispossessed of its supply; and in the event of the proprietor of the water desiring to change the rates of payment, this must be done through the medium of arbitrators duly nominated by both parties. It is held by the tribunals, that canals of irrigation are not to be regarded as works designed solely for the benefit of their original constructors. Certain rights and privileges, as the right of passage for the water across the lands of others, &c., have been granted in partial violation of the principle of private property, to facilitate the establishment of such works; and hence the general good of the community has to be considered, as well as the benefit of individuals who may be holders of government grants. When, therefore, the right of property in all running water in a country has been vested in the State, to be by it administered for the combined benefit of the public treasury and the agricultural community, the surest way of escaping all such injurious influences as I have just referred to, is for the Government to retain its right, and so to guard the grants of water it may make, as to secure all the interests of which it is the natural protector. The general principle on which grants should be made, appears to me to be by lease or contract for fixed periods of considerable extent, as from twenty to thirty years, the terms of such contracts reserving to the Government the general control of the waters, and the power of enforcing such police arrangements as are essential to sanitary or other purposes. The making of these leases renewable at certain intervals would give opportunities of introducing all such improvements as increased experience and knowledge had intermediately suggested, while their length would be sufficient to encourage the grantees to invest the capital necessary for the construction of the minor, but still very important works required for the passage and

distribution of the water. It is in India so directly the interest of the Government to stimulate the agriculture of the country, on which the great mass of its own resources depends, that the contracts would invariably be renewed on just and moderate terms; and I am sure that all parties concerned would be better satisfied under such a system, than if what may be called "perpetual settlements," similar to those of Lombardy, were introduced.

To illustrate the terms on which contracts of a temporary character are made on the great canals of Lombardy, I give here, as translated from the originals, the summary of the conditions applicable to those from the Naviglio Grande, the canal of Bereguardo, and the canal Martesana. Such contracts have reference to winter irrigation chiefly, as for that a larger volume of water becomes available than for summer irrigation, which is regulated almost universally by grants or leases in perpetuity.

"1. For the use of water in winter (*acque jemale*) the lessee is at liberty to employ an existing outlet which has no right to water during this season attached to it; provided always, that he shall be the actual proprietor of the works forming this outlet, or that the proprietor shall give his consent. In case of refusal on the part of the proprietor, the lessee shall be at liberty to construct a special outlet.

"2. The new outlets to be constructed within the banks of the canal ought to be established rigorously according to the forms and dimensions of the *modulo magistrale Milanese*. All the works connected with them must be of masonry in stone or brick, similar to those in use on the canals of the State.

"3. The lessee shall submit, with his application for water, a project accompanied by drawings, which represent in plan and elevation each outlet to be established,

showing distinctly the position where he desires to place it. This plan shall be submitted for the approval of the superior authorities; and its execution—superintended, at the expense of the lessee, by an engineer deputed by the administration of canals—shall be subject to whatever additional conditions it may be considered expedient to prescribe.

" 4. The works shall be constructed at the expense of the lessee during the first spring stoppage of the canal which may follow the sanction of the contract. They ought then to be subjected to a special inspection by the engineer who is deputed by the direction-general of public works. So soon as the water is readmitted into the canal, the new outlet is subjected to *gattelation*,* according to the method in common use, and by the individual just referred to. The key of the hydrometic sluice shall remain in charge of the agents appointed by the superior administration.

" 5. The lessee of the waters is bound, during the period of his lease, to maintain the works of the outlet in perfect order, according to the instructions of the government engineer. The necessary repairs must be made during the ordinary stoppages, and under the control of the engineer above referred to.

" 6. If, during the course of the year, the lessee shall find that the works have sustained injuries, he cannot

* I have already had occasion, in discussing the *modulo magistrale*, to refer to the functions of the *gattello*, or small catch with lock and key, which is fixed on the regulating sluice of each outlet, to prevent the entrance of too much water into the irrigating channel. The literal meaning of the word has, I presume, a quaint reference to the police duties implied in the old nursery rhyme,—

" When the *cat's* away,
The mice do play ; "

and steal, too, sometimes! The cat is a favourite in the technology of Italian irrigation ; the siphon is termed the " Salto di Gatto," or " cat-leap." In the ancient vernacular of Indian irrigation, the same work is termed " the camel's neck " —a much more apt descriptive name.

claim any stoppage of the canal to enable him to execute the necessary repairs; but he shall be bound to effect at his own expense, and while the canal is full, such provisional repairs as the government engineer may consider absolutely necessary for the protection of the water. He shall further be bound to close the outlet entirely, should such a step be considered absolutely indispensable. The definitive repairs shall then be postponed to the first stoppage.

"7. In addition to all expenses for the construction and superintendence of the outlet, the lessee shall be held responsible for all charges connected with the special survey and *gattelation*, and for all documents which the administration may be obliged to supply in connection with these various points.

"8. The use of winter water during each of the years for which the lease holds good, shall commence on the 9th of September, and terminate on the 25th of March in each year—always excepting the periods of stoppage for the clearance of the canals.

"9. The amount of the water-rent is payable in advance at the treasury of the imperial and royal administration of finance—that is, before the 9th of September of each year.

"10. In case of delay on the part of the lessee in paying the stipulated sum, the public administration shall have the power of closing the outlet, and of taking all legal steps necessary to enforce payment—that is to say, to recover all arrears, including interest at the rate of 5 per cent per annum. In general, there shall be neither suspension nor delay of payment on any pretence whatsoever, and the competent authority shall employ in each case such proceedings against the lessees in arrears as are usually taken by the administration of the finances in like cases.

"11. The administration reserves to itself the right of

closing the canals at the ordinary periods of each year, in accordance with the notice it may publish to this effect, at which times all clearances or repairs of water-courses, whether public or private, should have effect.

"12. In the event of any breach of banks or failure of supply occurring on any of the royal canals, of such a nature as to require immediate repair, it shall always be competent to the public administration to turn the waters at whatever period of the year the accident may occur, and for whatever number of days the repairs may demand, without the lessee having a right to claim under this present deed any compensation for damages whatsoever.

"13. The same rule shall hold good in the event of such an extraordinary diminution of the volumes of the rivers Ticino and Adda, and consequently in the supplies of the canals, as shall cause a deficiency of water for the ordinary purposes of navigation, and for outlets entitled to continued discharges; that is to say, in such a case the administration shall have the power of diminishing, or even of entirely suppressing, the outlets entitled to continued discharge, until the water shall have returned to its normal level, without the lessee having any claim to compensation. The necessity for such steps ought, however, to be duly stated to the direction-general of public works; and the precise extent to which it may be necessary to depress the hydrometric sluices, ought equally to be fixed in presence of the directing engineer of the canals.

"14. The lessee shall be bound to submit himself to all rules and regulations heretofore published, or which may hereafter be published, regarding the navigation, in so far as these shall have any special relation to the management of the irrigation outlets."

It will be seen from these rules that the Government reserves to itself very strict powers of interference and

control. Contracts under such conditions as the preceding last for any number of years; but the general limit is nine, as that is the usual period of agricultural leases throughout the country. It is, in my opinion, too brief even for Lombardy, whether as concerns land or water; and for India, the duration of the water-lease should correspond with that of the land, by lasting for at least thrice the time just specified. It is to be remarked that the government of Lombardy deals somewhat hardly with the holders of leases under these rules, in cases of defect of supply in the rivers or canals. All claim for damages is barred, but no remission of water-rent, in proportion to the injury caused, is promised. It may possibly be given in practice (although I am not aware that it actually is); but it would have been more satisfactory had the same open regard been shown for the interests of the community as for those of the State.

I may conclude this section by giving those articles of the law of the 20th of May 1806, by which the general conditions of grants of water are defined and regulated at the present time.

"ITALIAN REGULATION of the 20th May 1806, for IRRIGATION and the USE of WATER in WORKS.

TITLE I.—*Derivations of Water from Rivers, Torrents, and Public Canals.*

"1. No one can obtain possession of public waters, or erect works on the same, without the investiture or grant of the Government.

"2. The investiture or grant determines the quantity, the time, the manner, and the terms of the extraction, the passage, and the special use of the water or the building, and establishes the annual payment to be made accordingly.

"3. The arrangements of the preceding articles are not intended to injure the actual proprietors in the uses, buildings, and rights relating thereto, to which they enjoy a just title according to the laws and legitimate customs of their respective provinces.

"4. No new grant can be made to the injury of the rights of others. These rights shall be guarded by appropriate limitations in all such grants. To this end the petitions for grants shall be published, and all parties interested therein shall be heard.

"5. It is not permitted, under any pretence, to alter the outlets or fixed dams without the consent of the Government.

"6. In derivations effected by temporary dams, all works should be approved by the engineer-in-chief of the department, and reported to the direction-general.

"7. The engineers-in-chief are enjoined to take care that the waters granted for irrigation or hydraulic works be employed in all that affects the public interests, in accordance with the terms, obligations, and conditions imposed by the investitures or grants.

"8. To this end they shall have by them the register of the said grants, &c.

"9. If any one having a right to use water shall introduce any abuse, or neglect any duty connected therewith, the engineers are authorised to place things in their original condition, in accordance with the grants, reporting their proceedings to the direction-general.

"10. When disputes concerning water have reference solely to the interests of individuals, they shall be submitted for decision to the ordinary tribunals.

"11. When public interests are concerned in such disputes, they are reserved for the consideration of the public administration."

These general rules, with the special illustrations previously given, will, I trust, be sufficient to show how the government of Lombardy administers the waters of which it is the proprietor. I have not found any other details connected with the subject likely to be useful.

SECTION II.

RIGHT OF PASSAGE, OR "IL DIRITTO D' ACQUEDOTTO."

I have often already had occasion to refer to that right of passage which presents itself to notice at the very dawn of the existing legislation of Lombardy, and which for seven centuries has been regarded there as the principal feature in the *Magna Charta* of irrigation. I intend now to enter into some further details connected with it, as I am of opinion that its establishment, in clear form and just detail, would be of the utmost importance to the satisfactory development of irrigation throughout British India. It is not necessary for me to dwell on the history of the right, which, as we have formerly seen, comes first into view in distinct form during the earliest years of the thirteenth century. The construction of the Naviglio Grande rapidly wrought marked changes on the land through which it passed. Possession of its waters doubled and tripled the value of the soil, and hence a universal demand arose for the facilities of carrying them to distant points. In its earliest form the right of passage was rude enough. It was granted on condition that a certain supply of water should be allowed to the proprietor of the land from the water-course traversing his property, in exchange

for the soil occupied by it, the use of which was temporarily lost by him. It is a curious circumstance that this same method of compensation should present itself at a point so far distant as Northern India, where exactly the same idea originated on the first establishment of the rudely-defined right of passage which exists in that region of irrigation. "When the benefits of canal irrigation were better known and understood," says Major Baker, in his *History of the Canals West of the River Jumna*,* "they became the object of desire to many villages which had no ancient water-courses; and as these were, for the most part, at some distance from the canal, a necessity arose for arranging authoritatively, and once for all, the terms on which water-courses might be cut through the lands of other villages, than those for whose use they were intended. Under the arrangement proposed by Colonel Colvin, and sanctioned by the Government, it was made compulsory on all villages bordering on the canal, to permit the excavation through their lands of such water-courses as should be approved and considered necessary by the superintendent; *and any village so intersected by a water-course was entitled to as much water as it could raise by one 'daul'* (a large light wooden scoop used for raising water), *worked by two men.* No remission of land revenue was, I believe, made at the time, on account of land occupied as above described (at least no report on the subject was made by the canal officers to the collector), but it was duly considered in the present settlement, in which only cultivated and culturable lands were assessed." This is a very curious illustration of the similarity of ideas that occur to people placed in similar circumstances; for here we have an English officer proposing, and an English government sanctioning, in the nine-

* *Memoranda on the Western Jumna Canals*, p. 58.

teenth century, identically that plan which was in force in Lombardy, under like conditions, more than six hundred years before.

The establishment of the Naviglio Grande is represented in the old histories of irrigation to have been so much an object of universal interest, that no proprietors of the lands bordering it ventured, for some years, to call in question the first rude methods by which they were compensated for the loss of such portions of their lands as were occupied by the water-courses of their neighbours. The irrigable country was at that period divided into a comparatively small number of large fiefs, the proprietors of which seem to have succeeded in arranging amicably with each other for the circulation of the waters of the great canals. In cases where water was not allowed in exchange for the land occupied, it appears that, during the whole of the thirteenth and part of the fourteenth centuries, the compensation in money was practically limited to the simple value of the land, though, as we have before seen, the ancient statutes authorised one-fourth in excess. As time passed on, however, the demand for water gradually increased, and the proprietors of the land bordering on the canals generally began to find the repeated intersections of their properties of serious inconvenience. Hence resistance to the farther extension of irrigation became active—the right of private property was invoked in opposition to it; and from the middle of the fourteenth to the commencement of the fifteenth centuries, disputes and litigation before the tribunals were incessant. About the latter epoch the great fiefs had been broken up—the number of landed proprietors had become materially greater—rights were better understood, and their observance more decidedly insisted upon. A more careful investigation of the principles of the right of passage was

accordingly forced on the government and the legislative tribunals, from the necessity which arose for lulling to rest these discontents. It became evident that, while the utility of maintaining the right, when applied to such undertakings as involved the benefit of the entire community, was incontestible, yet modifications and limitations of it were just and necessary, when it was to be enforced on behalf of works which were directly for the advantage of individuals, and executed, not at the cost of the State, as the representative of the public interest, but of these individuals themselves. Into the latter class of works the element of public utility entered only in a secondary manner; and in reserving to parties desirous of irrigating their lands, the right of carrying the water across the properties of others, the conditions were now enforced in favour of the latter of the payment of a certain sum in excess of the estimated value of the soil occupied, and compensation for all injuries caused. Such excess of payment and compensation was restricted to the cases of private works; and thus, while that free circulation of the water was secured, without which no irrigation system can exist in efficiency, the sacrifice entailed on individuals was made as light as possible.

The right of passage was held from its first origin to be a simple servitude (*servitu*). The payment of the value of the land, with compensation for damages, and a certain fraction in excess, did not give to the proprietor of the water any right of property whatever in the soil forming the bed—*that* remained with the original landowner; and he continued to pay the land-tax and other burdens attached to proprietorship, so that if by any accident the water-course ceased to be employed for a certain time, the channel reverted thereupon to the first proprietor, and the right of passage became extinguished.

It became further clear, that merely to secure the proprietor of the land from pecuniary loss was not sufficient. In fixing the directions of their irrigation channels, proprietors of water might be influenced by various motives: they might desire to pass through land previously irrigated, that they might have the benefit of infiltration or over land, where there were indications of subterranean springs, of the supplies from which their water-courses would have the advantage; or they might wish to benefit one neighbour by carrying water near his land, or to injure another by a contrary course. The Government saw that it would be necessary to place limits to this freedom of choice, and hence originated the rule, that prior to any special direction being determined on for a water-course, evidence must be laid before the competent authorities that the line selected was the least injurious to all parties concerned. It is true that the application in practice of this principle continued to be a matter of some difficulty, as the professional advisers of the different parties occasionally disagreed on details; but generally its operation has been effective and beneficial. The prohibition against mixing in a common channel waters appertaining to different proprietors,* of maintaining all works of intercommunication, of keeping new channels at certain distances from pre-existing ones, and other matters of detail, gradually gave more and more perfect form to the servitude of water-passage, and relieved it from the objections which from time to time were urged against it.

The following are the provisions of the Austrian Civil Code for the Lombardo-Venetian kingdom, in so far as they affect the right of passage for water :—

* An ancient decision of the senate of Milan on this point is thus expressed— "Aquam ducere volenti, nemo tenetur dare proprios cavos sed de novo fieri debent."

"CHAPTER VII.—OF SERVITUDES.

"472. In accordance with the right of servitude, the proprietor of a thing subject thereto is bound to permit or to refrain from doing certain acts for the benefit of another. The servitude is a real right, which affects every proprietor of the thing subject to this servitude.

"473. If the right of servitude is attached to the possession of an estate, for the greater advantage or the greater convenience of the same, it is termed a servitude of property (*servitu prediale*). In other cases the servitude is personal.

"474. A servitude of property implies two proprietors of estates, one subjected to, the other in possession of, the right; to the first belongs the subject, and to the second the dominant estate. The dominant estate is designed either for rural economy or to another use."

Servitudes are hence divided into rural and urban.

. . . . . .

"477. The principal rural servitudes are—

. . . . . .

"2. To water cattle, to draw water, to divert or to conduct it.

. . . . . .

"480. The title to a servitude is founded on contract, or on the disposition of a last will, or on the sentence of a judge pronounced on the division of a common estate, or, finally, on prescription.

. . . . . .

"482. It is the rule in all that regards a servitude, that the proprietor of the subject-estate is not obliged to do anything himself, but only to permit to another the exercise of the right, and to abstain from doing that which otherwise as proprietor he might do.

"483. Consequently, the party having the right of servitude is bound to preserve and repair the things subject to the servitude. Provided that if the proprietor of the thing subject to the servitude does himself make use of the same, he shall be bound to contribute proportionally to the expenses; and he cannot otherwise free himself from this obligation than by surrendering the thing to him who has the right of servitude. Dissent on the part of the latter would not be sufficient to prevent this step.

"484. The proprietor of the dominant estate can exercise, according to his free will, his peculiar right, but the servitude ought not to be either extended or restricted more than is in conformity with its nature, and the end for which it was constituted.

. . . . . .

"496. The right to draw water belonging to another involves the right of access to it.

"497. Whoever has the right to bring water from the lands of another into his own, or to carry water from his own lands across those of another, has the power of constructing, at his own expense, the channels, the canals, and dams necessary to this end. The extent to which these works may be carried shall be determined by the wants of the dominant estate.

. . . . . .

"525. The servitude is interrupted if the subject or dominant estate perishes; but if the estate or edifice be re-established in its primitive condition, the servitude recommences, without being in any way changed or diminished.

"526. The servitude ceases when the subject and dominant properties are united in the hands of the same person. But if one of the united estates be alienated anew, without the record of the right of servitude having

been in the meanwhile legally effaced from the public books, the new proprietor of the dominant estate has the right to exercise the servitude."

I have thought it as well to give nearly all the articles of the Austrian code which affect the nature and exercise of the right of passage for water; but, among these, the only one which enters into any kind of detail on the specific conditions annexed to it is Art. 497. It will be seen, however, that this has none of the minute provisions which had gathered round the right during the many centuries it had been freely exercised by the people of Lombardy. In fact, the agriculture and industry of the country ceased to possess, under the operation of the Austrian code, that absolute right of water-passage which had formerly been attached to the legitimate possession of waters, from whatever sources derived; and by consequence, the most serious inconveniences would inevitably have arisen, had not the deep popular sense of the necessity for such free circulation tended to rectify the imperfection of the laws. The attachment to the custom was so firmly rooted in the national mind, that but few cases arose in which the passage was denied to parties desirous of obtaining it. A few such cases, however, did arise, and were followed by legal proceedings, which forced on the notice of the administrative authority the error that had been made in leaving so open to doubt all the main points connected with this right. Among these cases, the most important was one instituted by two brothers Sormani against the Marquis Cagnola, of which the details are given by Romagnosi, (*Trattato della Condotta delle Acque*, vol. i. p. 697-709). A brief outline of the case may perhaps be interesting, as illustrating the re-establishment of an important principle in the legislation of irrigation in Lombardy. The brothers Sormani claimed

the right of traversing a property of the Marquis Cagnola, which was surrounded by waters derived from springs on their estate in the district of Cernusco and province of Milan. A long discussion was, in the first instance, held between the opposing parties and their respective engineers, as to the line of direction the proposed water-course should follow, there having been a disposition to arrange the passage amicably, if possible. Matters, however, became so much embroiled, that, from disputing the mere direction, the Marquis Cagnola questioned the right of passage altogether, holding that, by the civil code of Austria, a servitude of this kind could only be established by contract, by the dispositions of a last will, by the sentence of a judge on the division of a property held in common, or, finally, by prescription; on no one of which bases could the brothers Sormani found their demand. The letters-patent accompanying the civil code had declared all other laws whatsoever abrogated, unless they had been specially maintained by imperial decree; and hence the ancient statutes and the modern laws of the kingdom of Italy were held to be alike null and void. The case was, in the first instance, tried before the civil tribunal of Milan; and by a decree of this court, under date the 11th June 1819, it was declared that the law of the 20th of April 1804 had not been abrogated by the publication of the civil code of Austria, but that its provisions were still applicable in all matters concerning the use of water in agriculture and industry. The tribunal held that the Austrian code regulated the exercise of the private rights of citizens in their different relations to each other, but that there was not reason sufficient to conclude that the legislature contemplated, by its publication, the entire abrogation of all pre-existing laws which regulated the wellbeing and the economic organisation of the State in its relations

to the rights and privileges of private parties. Hence it ruled that the laws of the 20th April 1804 and 20th May 1806, as tending to regulate the exercise of individual rights in relation to the interest of the community and the public good, should be considered in full force in the absence of any special act of abrogation. The brothers Sormani accordingly obtained the right of passage across the lands of the Marquis Cagnola under the provisions of the laws in question.

This decision was then carried before the imperial and royal court of general appeal in Milan, by which it was reversed, and the right of passage was altogether denied. The grounds of the new decision were, that the imperial patent of the 28th September 1815, in referring to that of the 1st June 1811, declared that the Austrian code should form the sole and single rule for all the provinces appertaining to the government of Milan, in substitution of all other laws or statutes whatsoever; that by article 10 of the said code all common customs were abolished, except in cases where these were referred to in the laws; that by article 11, only such statutes of single provinces should have the force of laws as were expressly confirmed by the legislature; that by the patent of the 1st June 1811, various pre-existing statutes had been declared in full vigour, but that among these the agrarian regulations as concerned waters were not included; that to maintain the laws of 20th April 1804 and 20th May 1806 in full force, involved such an interference with the right of private property, as defined by articles 354 and 362 of the code, as would require an express confirmation of the supreme authority; that for objects of declared public utility alone could individuals be deprived of any portion of their private properties; and that, in the present case, the object was not of this nature. The Marquis Cag-

nola was accordingly absolved from the sentence of the civil tribunal of first instance; and it was decided that the passage across his land could be granted only at his own will.

The matter was not, however, allowed to rest here. The local administration saw clearly that to abrogate the right of passage was to inflict a severe blow on the agricultural and industrial interests of the country; and it was therefore determined to carry the case finally before the Aulic council of Vienna, so as to obtain the highest authority for its ultimate decision. This tribunal, by a decree under date the 17th August 1820, reversed the decree of the court of appeal, upheld that of the civil tribunal, and declared the laws of the 20th April 1804 and 20th May 1806, in full force. In the exposition of the grounds on which its decision was based, the Aulic council remarks—"Running waters are in this region the necessary aliment of the soil—they increase it fertility, and they insure its products. To them are due those returns, of which, in defect of rain, agriculture would be wholly deprived. When water is thus useful, and contributes thus powerfully to the increase of the products of the soil, we can entertain no doubt as to the influence which its employment exercises on the public good. The new civil code is in no way opposed to the recurrence on special matters to pre-existing administrative regulations. But agriculture on the one hand, and the usages connected with running waters on the other, occupy an important place among such specialities; hence the promulgation of the new law has in no degree abrogated the laws and statutes connected therewith, which ought, according to the terms of the Austrian code itself, to remain in force, so long as they are not formally abrogated."

A special notification of the government of Milan, under date the 25th July 1825, is to the following effect:—

"It is ordered that the Italian laws of the 20th April 1804 and the 20th May 1806, shall have full force in all matters connected with the legal servitude of the passage of water."

This question having been thus finally and satisfactorily decided, and the right placed on the old basis, I may now give the articles of the law in question, whereby its exercise is defined and regulated at the present time.

"*Law of the 20th April* 1804.

"*Art.* 51.—Every individual is bound to cede the land necessary for the channels, the rectifications of the directions, the alteration of the courses, or the embankments of rivers, canals, or public drainage channels; and, in general terms, for all works connected with water, which are designed for the public good, receiving compensation for the same at a reasonable rate.

"52. Whoever desires to make use of waters, public or private, of which he is the legitimate proprietor, for purposes of agriculture, or for the movement of machinery and hydraulic works, may carry them across the lands of others, paying the value of the soil occupied by the water-course, according to an estimate of the same, with one-fourth in excess; and coming also under an obligation to maintain the water-course, banks, works, &c; and further, to indemnify the proprietor of the land for all damages whatsoever which the said land may sustain.

"53. Such water-courses should be carried across that portion of the estate where, according to the judgment of practical men, the least possible injury shall be caused to the proprietor or possessor, reference being always had, however, to the convenient derivation of the water.

"54. Lower lands are bound to give passage to waters

flowing from higher levels. In addition to the obligations imposed by the preceding articles, the proprietor of the upper lands is bound to defray the cost of such drainage channels as may be necessary; and of such works of defence as may be required to protect the lands through which the waters pass, as also to repair any damage which at any time the said lands may sustain. The preceding article does not affect special agreements between proprietors, nor rights of servitude legitimately acquired."

The only addition made by the law of the 20th May 1806 to these rules is the following:—

"*Art.* 16.—Whoever desires to introduce water into a public canal, with the view of extracting it again at a lower point, shall submit his claim to the direction-general. This will be decided in accordance with Art. 4, (*i.e.* so as to cause no injury to the rights of other parties). Objections to this arrangement shall be disposed of by the public administration."

This article forms the sole reference to the use of pre-existing canals which I have found in the present legislation of Lombardy: it restricts such use to the case of public canals only, and I believe no private water-courses are ever now subjected to any such claim. We shall hereafter find that the Piedmontese have arranged this point admirably, but in Lombardy it is still less clearly defined than it ought to be.

I have had occasion to refer to the importance of surplus irrigation waters, or *colature*, to the agriculture of Lombardy; and I may state here that it has been established by judicial decisions, that parties possessing legitimate rights to such waters, may claim the same privileges

as belong to original derivations from rivers, canals, or springs. In a word, the right of passage is applicable, with entire generality throughout Lombardy, to all waters *legitimately possessed*, from whatever sources they may be obtained; and so long as the conditions prescribed by law are complied with, their circulation is free and facile. Nothing contributes so much to this most valuable result as the high character and qualifications of that immense body of hydraulic engineers which has been created by the general development of the system of irrigation, and its intimate relations with the rights of property and the progress of improvement. It is to members of this profession that all those questions connected with compensation, whether for the soil occupied or the damages caused by the works, with the lines of direction which channels should follow, so as to cause the least possible injury, and all other particulars of like character, are referred. The judicial authorities base their decisions in all questions of hydraulic art on their evidence; and under the general name of *periti*, we find them holding an important position in the whole course of the legislation of irrigation, from the earliest times to the present day. The discharge of the duties required at their hands is always delicate and difficult, but as a class they are universally respected for general efficiency, good faith, and professional honour. I owe so much to the kindness of many among them, that I may be permitted to bear my testimony, in passing, to their worth and ability.

SECTION III.

MEASUREMENT AND DIVISION OF WATER.

No universal rule has yet been established in Lombardy for the measurement and division of water in irrigation. It is not necessary that I should trace again the history of the efforts which, at various times and under various fortunes, have been made to introduce such a rule. In the history of the great canals of the Ticino and the Adda, I have given sufficient details of the difficulties which have hitherto prevented the establishment, either of a general unit of measure or of a definitive measuring apparatus. The existing legislation on the subject is embodied in the following articles of the law of the 20th May 1806 :—

"*Art.* 13. Pending the establishment of a uniform measuring apparatus (*modulo*), and a unit of measure for the public waters, regulated outlets (*bocche modellate*) shall be constructed in the forms and with the dimensions in use in their respective districts.

"14. For all such localities as possess no measuring apparatus, the direction-general of public works shall prescribe one suitable to the circumstances of the places and of the canals.

"Where it is necessary to divide waters, the division shall be effected after the manner and under the conditions which may be prescribed by the direction-general of public works."

Each province, therefore, continues to use its own measure, under the general control of the direction of

public works, and outlets are regulated in the Milanese according to the form of the *modulo magistrale;* in Mantua, according to the *quadretto Mantovana;* in Verona, according to the *quadretto Veronese;* and in Lodi, Brescia, and Bergamo, according to the local forms of these provinces. As I have already described all of these forms in the chapter on the methods of measuring waters in use throughout Lombardy, it is not necessary to say anything more about them here.

In illustration, however, of the manner in which the contracts are generally made under existing arrangements, I may give in this place a translation of one for the perpetual lease of a certain volume, say 1 cubic foot per second of water, for summer irrigation.

TITLE.—*Lease for* 1 *cubic foot of Summer Water in Perpetuity.*

"In virtue of these presents, which shall have force and value as a public and authentic act, A conveys, and has conveyed effectively, under the title of a perpetual lease to B, who accepts it for himself and his heirs, the right to 1 cubic foot per second of water, derived from the canal M——, of which he, A, is the proprietor; this volume of water being delivered, as is explained hereafter, for the irrigation of the property of B.

"In addition to the rent or perpetual payment, which shall be £26 yearly, he shall pay, once for all, the sum of £100, in satisfaction of the right of entry, which sum A acknowledges having already received from B for this object, granting hereby a receipt for the same.

"The present contract of perpetual lease is made and accepted between the parties above named, under the clauses, charges, conditions, and obligations hereafter specified:—

"1. The delivery of 1 cubic foot per second of water shall be made from the canal M——. During summer the discharge of this water shall be constant from the 10th of April to the 11th of June of each year. From the last-mentioned date to the 15th September, B shall have, during forty-two hours, the enjoyment of a volume equal to four times the first-mentioned quantity, or 4 cubic feet per second, in a rotation of seven days; with the exception always of forty-eight hours in every twenty-eight days, during which time it is customary to effect the clearance of deposits from the canal itself. During winter the original quantity of 1 cubic foot per second shall flow constantly from the 10th of October to the 15th of March of the following year; with the reservation, that at two periods of the year—that is to say, between the 15th of March and the 10th of April, and between the 15th September and the 10th of October of each year—the complete clearance and repairs of the said canal shall be executed according to the practice now in force.

"2. The enjoyment of the volume of water appropriated to B, for the times and after the manner above prescribed, shall commence from the 10th of April next, to continue for ever without interruption.

"3. The *modulo* by which the quantity of water shall be measured at the different periods above specified, shall be constructed in masonry, of bricks or cut stone, following the *magistral* form; but the chambers which are attached to it shall be complete or incomplete, covered or open, according to the will of B and his representatives. The hydrometric sluice (*paratoja*) placed at the head of the *modulo*, shall be provided with a chain and padlock, of which the key shall be lodged in the hands of the guardian appointed by the proprietor of the canal. This *modulo* shall be established and maintained in repair by

B in such manner as that it shall have a total discharge of 4 cubic feet per second; it being, however, clearly understood, that in spring and winter, when the discharge is limited to 1 cubic foot per second, according to the preceding conditions, the opening of the *modulo* shall be reduced accordingly.

"4. Should it so happen that by any accident, such as breach of embankments, or by any other cause independent of the will of A and his agents, a deficiency of water, either entire or partial, shall occur, neither the perpetual tenant of the water, nor his administrator, shall have any right to refuse payment of the money-rent agreed upon, provided always that this want of water shall not last longer than three entire days: if this period be exceeded, the proprietor of the canal shall be bound to compensate for the deficiency, by supplying to the tenant, when the canal reaches its usual level, the entire quantity of water of which he may have been temporarily deprived.

"5. The tenants of the water, and every other person whatsoever, are expressly forbidden to interfere in any way with the *modulo*, or with the outlet of the water-course, or with any of the works dependent upon these, or with the canal itself, under penalty of having to repair all damages to which such acts of violence may give rise. B shall be at liberty to institute an examination of the aforesaid *modulo* by a professional man of his own choice, who will act in co-operation with the engineer of the canal, to the end that the entire regularity of the work may be ascertained.

"6. The repairs of the canal and its works of art, with the general and partial clearances it may require, shall continue to be effected at the cost of A, the proprietor of the said canal; but the same kind of works which may be executed on the channels or irrigating courses, situated

below the *modulo* at the head, shall be at the charge of B. Whatever changes of volume may occur in the supply of water below the same point, shall be to the profit or loss of the same party.

"7. The payment of the perpetual rent, fixed above at £26 yearly, shall be made during the month of June of each year, commencing with the year now current.

"8. The payment of the said sum, or its redemption in terms hereafter specified, shall always have effect in Milan at the dwelling-house of A, in true coin of gold or silver current in the realm, according to the terms of the Austrian civil code, to the exclusion of all paper-money, or other representative sign of ready money, even when such paper-money may be sanctioned by the law. In the event of B or his representatives persisting in paying the whole or any part of the sums due by them in paper currency, A and his representatives shall have the right of closing the outlet of distribution, and of refusing to grant it again to B.

"9. In case either of actual disputes, or of the occurrence of circumstances whence these might arise, the tenant shall have no right to delay the payments stipulated above. He shall not have the right of even commencing any action at law against the proprietor of the canal, until he shall have certified beforehand that he has paid exactly all the claims which were due by him. In the event of the tenant being in arrear more than a month in fulfilling the stipulated obligations, the proprietor of the canal, or his representatives, shall have power to close, and to keep closed, the outlet at the head during the whole time that the delay in payment of the amount due may last; and the tenant shall be not the less bound to pay the full amount of the ordinary rent, without any deduction on account of the time during which he may have been deprived of the water under the operation of this article.

"10. The tenant shall have the power of redeeming the annual payment stipulated above, by giving the proprietor of the canal three months' notice of his desire to this effect, and by paying one hundred pounds of capital for four pounds of rent. The redemption may be partial, provided always that the portion to be redeemed shall not be less than one-third of the total annual water-rent, and that the payments shall be made in the manner above prescribed.

"11. In all matters connected with this contract, the contracting parties agree for themselves and their heirs to submit to the jurisdiction of the judges and tribunals sitting in Milan, as being the place where the payment for the water granted is to be made, in accordance with article 25 of the decree of Government, dated 29th September 1819.

"12. The present agreements and obligations bind the contracting parties, and their heirs and successors, and such parties as become debtors by delay in payment of the rent stipulated, to submit themselves to all the conditions above made and provided for this contingency. The expenses of the preparation of this deed, and of the authentic copy thereof to be delivered to A within a fortnight, shall be at the sole charge of the tenant."

A special agreement of this kind will probably give a clearer idea of the course actually followed in the practical division and distribution of the irrigation waters, than any other method. There is, of course, modification in detail among the immense numbers of such contracts yearly made—occasionally, instead of the *magistral* form of measuring apparatus being prescribed, a certain sum per *pertica*, or other superficial measure of land, forms the basis of the contract; or in the case of rice-lands, the

proprietor of the canal agrees to furnish the full supply of water necessary, on receiving a certain specified proportion, generally one-fourth of the gross produce. For ordinary irrigation the contracts describe, in clear detail, the different pieces of land for which water is required, noting their position, their superficial contents, and other important points, all of which have to be verified and certified by a surveyor appointed by the proprietors of the canals. The usual period of rotation of fourteen days is held to be implied in all contracts of this kind, unless express stipulations are made for a different one.

For rice-lands the proprietor of the canal, or his agent, binds himself usually to supply the water necessary to place and to maintain in the requisite state of irrigation the lands, as described in a special statement annexed to the agreement. The principal conditions of the bargain are generally, that all the works undertaken shall be subjected to constant superintendence by a practical man, nominated by the proprietor of the water; that the seed shall be furnished by the said proprietor, and that the water-rent in kind, consisting of one-fourth of the gross crop, shall be paid, independently of the seed which is to be returned each year to the proprietor, and on no account to be included in the calculation of the gross produce. The proprietor of the canal also reserves to himself the power to break the contract, if, on experience, it be found that the land is essentially unfit for rice-cultivation, from excess of porosity or other causes. It is further usual for the proprietors of the rice-lands to agree to pay a small sum of money in addition to the quarter of the produce, as cost of superintendence.

The example I have given is a fair general type of the ordinary agreements; but there is one point of some importance omitted in it. This regards the disposal of

the surplus waters, the right to which is almost invariably reserved to himself by the proprietor of the canal. This is usual in all ordinary irrigation; but I believe it is never otherwise in irrigation of rice-lands, where such surplus waters, or *colature*, are of large volume, and generally possess very fertilising properties, from holding manure of various kinds in suspension.

SECTION IV.

DERIVATIONS OF WATER FROM SPRINGS, (FONTANILI SORGENTI).

The common origin, in the great water-bearing stratum of light sand or gravel which underlies the surface-soil of so large a portion of the plain of Lombardy, of that immense number of natural springs whose waters have been pressed into the service of irrigation, led at a very early date to precautions being taken to protect the interests of their respective proprietors. It was soon observed that new springs, opened in the vicinity of pre-existing ones, drew away from these latter a portion of their volume. Water-courses similarly opened were found to have a like effect, and proprietors of land were not long in availing themselves of such experiences. Among the earliest of the statutes of Milan, we find (cap. 242) one to the following effect:—"In future, no one shall be permitted to establish a spring-head (*testa di fontana*) within a less distance than 8 *trabucchi* (67.88 English feet) from the bank of any public river. The party breaking this law shall be subject to a fine of 100 imperial *lire*, to be appropriated, *ipso jure*, to the commune of Milan, and shall

further be compelled to re-establish the locality in its original state at his own expense." Following this, (cap. 243), we have another, prescribing that "it shall not be permitted to form a new spring within a less distance than 300 *braccia* (493.6 English feet) of any fountain-head or spring of water (*testa di fontana e sorgente di acqua*) previously existing, under a penalty equal to that fixed by the foregoing statute."

The legislation of modern times has discontinued the prescription of specific distances, more judiciously leaving these to be determined by the evidence of practical men in each particular case, according to the peculiarities of soil, depth of the springs, and other physical circumstances likely to influence the question. The law of the 20th April 1804 on this point is to the following effect:—

"Art. 55. It is forbidden to excavate or open springs, or heads of springs, water-courses, and channels; as also to deepen or increase the dimensions of excavations, or springs actually existing, in the vicinity of rivers or canals, within the distances which, according to the judgment of practical men, could lead to injury to the rivers or canals, or to their banks."

The law of the 20th May 1806, in extension of the preceding, provides thus in Art. 12—"Saving the prescription in Art. 55 of the law of the 20th April 1804, it is permitted to every one to excavate springs on his own land, and to conduct the same, respect being always had to any rights which other parties may possess."

The distribution of water, whether from springs, canals, or rivers, when regulated by horary or diurnal rotation, is invariably the subject of special agreement, in which all the details of time and quantity are carefully noted. I have already given in a previous part an example of this

form of distribution; and as there is no special legislation connected with the subject, I need not now enter into any further details regarding it.

SECTION V.

GENERAL ADMINISTRATION AND POLICE.

In dealing with the waters of the country generally, the government of Lombardy appears to have found it most effective and convenient to organise local associations of the parties specially interested in these, and to vest in such bodies certain powers of self-administration through the agency of elective councils. This associative principle dates from a very early period, in the Milanese especially, and some of the existing corporations trace their origin to the commencement of the twelfth century. They have held together during the various convulsions which have disturbed the country, and their rights and privileges have always been respected under all the different governments which have succeeded each other in this region. There are no points of special interest connected with the ancient organisation of these associations. The rules of the whole are now founded on the general provisions of the laws of the 20th April 1804 and 20th May 1806, which, although originally designed to regulate societies formed for purposes of drainage and general improvement, were declared by the Aulic Council, in a despatch dated 28th September 1837, to be equally applicable to associations for irrigation duly authorised by the supreme authority. At present, both in the Lombardian and Venetian provinces, societies may be constituted

for every purpose connected with the use or control of the waters for drainage, for irrigation, for maintenance of the embankments of the rivers, for improvement of marsh-lands, whether by removal of the water, or by *warping* (*colmata*) for machinery, and for sanitary purposes. I propose, accordingly, to give in this section the general provisions of the laws by which the organisation of these societies is regulated, and to illustrate them by examples of their application in special cases. This appears to me to be the best plan I can adopt, to exhibit the interior machinery of a system which has a special interest in connection with the irrigation of Northern India, from our having found, in the same associative principle, our most powerful means of developing the capabilities of our irrigating canals in that region.

"I. *Organisation of the Associations.*

"1. All proprietors interested in special hydraulic works shall be formed into such number of associations as may best suit their common interests and the territorial divisions of the kingdom.

"2. All existing associations shall be preserved, with such modifications or additions as may appear desirable.

"3. The list of associations shall be definitively published during the course of the following year.

"4. The associations are subjected to the control of the prefecture, and shall exercise their functions according to such rules and regulations as may be prescribed by the superior authorities.*

* Decree of 6th May 1806, Arts. 71, 72, 73, 74; Decree of 20th May 1806. Translation from the *Raccolta di Leggi, &c., delle Acque e Strade del Regno d'Italia.* Milano, 1806.

"5. The properties benefiting by one drainage or irrigating canal constitute a district (*comprensorio*).

"6. All the proprietors of estates situated within a district constitute an association (*societa*).

"7. If the extent and circumstances of a canal should so require, it may be divided into several sections; each section may have its own district, and each district its own association.

"8. Each association shall be represented by a delegation.

"9. The number of delegates shall be determined by the direction-general, in proportion to the wants of the district.

"10. The proprietors in each district shall nominate the members of the delegation by ballot. To this end the prefecture shall convoke the proprietors at a specified time and place. The assembly shall be presided over by the prefect, the vice-prefect, or one of their deputies.

"If the number present shall not equal a third of the total number of the proprietors, those actually present shall select the delegates from three lists composed of the larger proprietors.

"11. One delegate shall be removed from the delegation biennially. The retiring delegate shall be selected by lot from among those first elected; afterwards the senior member shall retire.

"The retiring delegate may be re-elected indefinitely.

"12. The delegation has a president, whose tenure of office lasts for one year. All the delegates succeed to the presidency in due order. Among those first elected, the majority of votes in the election shall regulate the order of succession. Subsequently, the rule of seniority shall be observed.

"13. The delegation shall determine the days of its

ordinary meetings. The prefect, the vice-prefect, and the president, can, on necessary occasions, summon extraordinary meetings. The president shall cause the decisions of the delegation to be executed in all cases where no special member has been nominated for this purpose.

" 14. The ordinary duties of the delegation are to superintend the canals with their outlets and banks, as also the works of such other canals as may traverse or surround their district, to maintain all these in repair, and to collect the funds necessary for these objects.

" 15. The delegation shall decide on all matters within its powers by simple majority of votes.

" 16. When new projects interesting to the entire district come under discussion—such as the construction of new canals, the enlarging or prolonging of old ones, the formation of outlets or tunnels under rivers, or similar works involving extraordinary outlay—then the whole of the proprietors of the district shall be convoked, and shall proceed to the election of as many extraordinary as there are ordinary delegates.

" 17. The union of the new with the old delegates forms an extraordinary delegation, which shall decide on the proposed works, and the means of executing them.

" 18. The result of the deliberations of the extraordinary delegation shall be submitted for approval to the direction-general. On the works and means of execution receiving the approval of the superior authorities, their completion is intrusted to the ordinary delegation.

" 19. Each delegation shall have an accountant and a cashier.

" 20. In such districts as have relations with foreign powers, the conventions and customs in present force shall continue.

" 21. In cases of new canals, or improvements of land

by drainage or warping, the districts and associations shall be formed in accordance with the foregoing rules.

"II.—*Superintendence of the Canals, Outlets, and Embankments belonging to a District.*

"23. There shall be nominated, for the superintendence of the canals, outlets, and embankments belonging to a district, such number of guards (*custodi*) as the delegation may consider necessary.

"24. The delegation shall prescribe the police rules for the regular protection of these objects.

"25. The ordinary engineer shall visit triennially, and oftener if requisite, all the canals in his department: he shall then examine the interior condition of all the fixed works, note their wants, defects, or abuses, propose to the delegation the appropriate repairs, and shall inform the engineer-in-chief of the whole, who will then report to the direction-general. Should the delegation not be prepared to execute the works suggested, the engineer-in-ordinary will report accordingly to the engineer-in-chief, who will then submit the question to the direction, with his observations and opinion upon it, for the decision of the superior authorities. During such visits the condition of new land-improvements (*bonificazioni*) should be especially noted.

"26. In times of floods, or inroads of the waters, the extraordinary guard reserved for such occasions shall be bound, in operating on any works belonging to any particular district, to act in accordance with the wants and usual customs of the localities.

"III.—*Works connected with the Canals of Drainage.*

"27. With the view of showing clearly the interior condition of the principal canals, fixed marks shall be established at every 1400 feet along their banks, on which shall be shown the depth that each section of the channels ought to have. This depth shall be shown in local measures, with the equivalent Italian measures, on each of the marks above referred to.

"28. Each delegation shall fix a certain minimum depth for each canal within its district; and when filling-in above this line takes place, recourse should immediately be had to excavation. The depth in question should be approved of by the engineer-in-chief.

"29. The clearances of the canals should be effected twice a-year, at least.

"30. Should it happen that, by any river breaking its embankments, portions of canals are blocked up, the delegation should instantly re-establish the same.

"IV.—*Distribution and Realisation of the Expenditure.*

"31. A preparatory estimate of the expense required for the public and communal canals included within a district, shall be made by an engineer or other qualified party. The same course shall be followed in all cases of extraordinary works.

"32. The delegation shall prepare annually an assessment list, the basis of which shall be the amount of annual public burdens on each property, and the estimates of the probable expense required for the works, as given by the engineer.

"33. This assessment list shall be submitted for the approval of the prefect, who shall forward the same for

the consideration of the Magistracy of Waters. On receiving the sanction of the preceding parties, the assessment shall be enforced according to existing agreements and customs.

"34. Where no special agreements or common customs exist, the proprietors subject to the assessment shall be arranged in different classes, according to the amount of benefit they derive respectively from the works.

"An engineer-in-chief, selected by the president of the delegation, shall propose the classification of the proprietors and the different proportions in which the separate classes shall contribute to the expenses.

"This proposal shall be made public, so that the proprietors may present any objections they may have to it before the Provincial Delegation, within a term to be fixed by this body. The Provincial Delegation,* with the concurrence of the Provincial Congregation,* shall report on the case to the Government. On receipt of the approval or alterations of the superior authorities, the quota fixed for each class of proprietors shall be distributed among the individuals composing this class, in proportion to the revenue-survey valuations (*in ragione del valore catastrale*) of their respective properties.

"35. In collecting this assessment, the cashier shall exercise the same powers as are prescribed by the laws for the collection of the direct taxes.

"36. The fines imposed on parties breaking the existing regulations belong to the association, and shall be lodged in the treasury of the same. Whatever other profits may in any way accrue, shall be similarly deposited in the treasury at the disposal of the delegation.

"37. The cashier shall make payments on orders

* These are local bodies, established in each province for the management of its internal affairs, as connected with roads, bridges, canals, &c.

signed by the president, one delegate, and the accountant. He ought to be required to furnish a sufficient amount of security. He is appointed by the presiding body on its own responsibility. The entire amount of each rate imposed shall be placed to his debit five days after it has become due, whether it has then been received by him or not.

" 38. At the end of each year the superintending body shall present to the provincial delegation the accounts of the expenditure, with a statement of the debits and credits of the treasury; and when these have been approved by a vote of the provincial congregation, they shall be published, and a copy forwarded to the Government.

" 39. In case of several channels, which cannot conveniently be included within one district, having a common escape-canal or other works, the expense required for the protection and maintenance of the said works shall be divided among the districts using them, in proportion to their respective interests in them, excepting always any agreements in force to a different effect.

" 40. If the defence of an embankment concerns several districts, the expense of repairing it shall be divided among them according to their respective interests, saving agreements in force to the contrary.

" V.—*General Arrangements.*

" 41. Associations of proprietors interested in drainage, land-improvement, or irrigation, are subject to the inspection of the Provincial Delegations, and are placed under the *guardianship* (*tutela*) of the political administrative authority. They exercise their duties according to the rules and regulations prescribed by the superior authority.

" 42. All works appertaining to associations shall be

made by regular contracts. To proceed otherwise, and to execute the works by daily labour (*per economia*), requires an express order from the Government, who will decide on the case and the necessity. In contracting for the annual repairs of the works, the contracts shall be made for nine years. The Government may alter this arrangement under special circumstances.

" 43. The channels shall be furnished, not only with the appliances necessary for opening or closing them with facility, but also with supplies of all the materials which may be required to strengthen and protect them in time of floods. All arrangements that concern the defence of embanked rivers are under charge of the engineer-in-chief and his subalterns.

" 44. Where the respective titles do not otherwise provide, the volume and the special regulations for each outlet from the rivers shall be fixed in such manner as that no injury may result to the interests of any of the proprietors belonging to the district. The same care shall be observed in the use of turbid waters employed in operations of improvement by deposits.

" 45. Objections made by the proprietors within a district to the proceedings of the presiding body (*la presidenza*) shall be considered by the provincial delegation, which, having verified the facts, and submitted them to the provincial congregation, shall decide each case according to its merits. If the objections should involve points of great importance, the provincial delegation shall submit them to the Government, and shall await its instructions before coming to any decision.

" 46. Each delegation shall present to the provincial delegation a project of regulations for the careful protection of all the matters committed to its charge. These

regulations shall not have force until approved of by the protecting authority (*dell' autorita tutoria*).

" 47. The laws, regulations, edicts, punishments, and fines, established for the associations of drainage, improvement, and irrigation, prior to the publication of the law of the 20th May 1806, shall continue in full vigour in all cases for which no provision to the contrary has been made by the law just referred to."

The preceding provisions form the framework of all the associations for purposes connected with the use of water in agriculture or general industry throughout Lombardy. They are fruits of the organising genius of Napoleon ; and so satisfactorily have they been found to work in practice, that the Austrian government has adopted them in their integrity. The series of decrees, of which the preceding form only one part, embraces the entire organisation of the roads ; the embankments of the rivers, so incalculably important in this region; the administration and police of river, lake, and canal navigation; in fact, the entire machinery of communication by land and water irrigation, and protection from floods. I have, however, restricted myself at present, as much as was possible, to those details peculiarly affecting irrigation ; and I proceed to give some examples of the manner in which the general rules just detailed are applied in special cases.

The river Olona is one of the minor streams of the Milanese, which, rising among the high lands of Varese, flows from thence to Milan, contributing a large portion of its volume to purposes of irrigation. The association of proprietors irrigating from this stream is the most ancient in the country : the waters were granted originally to the Cistercian monks of Chiaravalle, then, and for long afterwards, the great owners and employers of nearly all

the streams in the vicinity of Milan. The proprietors, or tenants of lands irrigating from the river, were formed into an association, which appears on record at the close of the twelfth century, under the name of "The Employers (*Utenti*) of the Olona." To this body a power of self-administration was committed; and from time to time it raised claims to entire independence of the administrative authority of the State, on the ground that its right of property in the stream was absolute. This claim, however, was never admitted, and in course of time was abandoned; so that, like all other bodies of the same class, the association of the Olona is now subject to such administrative and police enactments as are sanctioned by the supreme authority. A council of administration, nominated by the proprietors, according to the rules prescribed by the law of the 20th May 1806, regulates the interior economy of the association; but all works projected for the extension or improvement of irrigation must be submitted to, and approved of by, the Direction-General of Public Works at Milan, before they can be executed.

The latest regulations for the river bear date the 11th May 1812, and are to the following effect:—

River Olona.

Preamble.—With the view of terminating the grave disorders and abuses which have been introduced on the river Olona, and of maintaining in full vigour the laws and proclamations which have been issued at various times for the protection and the better distribution of its waters, to the advantage at once of the public, and of individuals, especially that of the 12th September 1773, by the conservator Verri; as also that of the 7th of October 1774, by the Duke of Modena, Francesco III., governor of

Milan, and in conformity with Art. 43 of the regulation of the 20th of May 1806, for associations interested in drainage and improvement, and with the ordinance of the Direction-General of Public Works, under date the 12th May 1808.

The delegation of the said river, authorised by the Direction-General, and by the Prefecture of the Department of the Olona, and adhering to the afore-mentioned laws and proclamations, without in any way detracting from the same, has published the following

General Regulations for the River Olona.

1. No one shall be permitted to extract, derive, or use the water of the river Olona, either directly or indirectly, unless he is possessed of the right and privilege so to do, under a penalty for each contravention of 230 *lire* (about £8), whereof two-thirds shall be lodged in the treasury of the delegation, and one-third be granted to the guardian or the informer (whose name shall be kept secret, should he so desire). In enforcing the said punishment, all such proceedings as are within the competence of the delegation shall be had recourse to.

2. All parties claiming to have right and privilege to use the said water, shall have two months, from the period of the publication of this regulation, allowed them for the production, before the Chancellor of the Delegation, of legal proof of the right or privilege they claim. They shall specify the time and the horary period (*orario*) for the use of the water, the outlets, the works, the quantity and nature of the meadows, the district in which they are situated, and the corresponding numbers of the Revenue Survey Map, so as to facilitate the proceedings which it may be necessary to adopt in each case. If the time above

specified is allowed to elapse without the production of proof in the manner just prescribed, the recusants, without any other intimation, and without hope of farther delay, shall be irremediably excluded, *ipso jure*, from the use of the said water, and shall be bound to remove their outlets at their own expense.

3. Within the same period of two months, all breaches in the banks, or injuries to the heads of channels within 12 feet of the river, should be carefully repaired, so that no leakage of water may occur within this limit, under a penalty equal to that specified before, to which all proprietors or tenants of lands whereon such breaches may be found shall be subject, and the repairs of any damages caused by these shall be made, *ex officio*, at the expense of the parties violating this order, without any farther intimation.

4. Neglect in removing, within fifteen days, the dams, impediments, deposits, or any other matters which either interfere with the free course of the water, or force larger supplies than are just into any of the outlets, shall be subject to the same penalty, and the removal of the said impediment shall be effected *ex officio*, at the expense of the parties contravening this order.

5. The outlets, large or small (*le bocche e bocchelli*), which have not their sills made of stone, or which may be broken, as also the dams of mills which are not properly restricted, ought to be established in accordance with the forms prescribed in the new statutes* and these rules, within the period of two months, under the penalty before specified. They shall be surveyed by the engineer of the delegation, who will proceed, under the authority vested in him, to execute all such repairs or alterations on the

* These are very imperfect, fixing merely the superficial dimensions, and the height of the sills of the outlets above the bed of the stream.

outlets as may be necessary to insure their conformity to the regulations.

6. All outlets, of which the sills are placed at levels lower than those prescribed by the proclamation of the 15th of May 1643, in execution of a decree of the late senate, dated the 5th of the same month, shall, under the sanction of the delegation, be reduced, within the term of one month, to the limits therein prescribed; that is, all situated above Castellanza shall have their sills on the same level as the inlet of the first mill immediately below each head; from Castellanza inclusive to Nerviano exclusive, the sills shall be four inches higher than the level of the inlet of the first mill below each head; and finally, from Nerviano inclusive to the end, the sills shall be only 2 inches higher than the inlet of the mill next below each head. The preceding shall be observed under the penalty before fixed.

7. All outlets not constructed after the manner prescribed by the order of the 14th May 1575, ought, with the previous sanction of the delegation, to be forthwith established according to the conditions therein prescribed —namely, with the sills and sides of the outlets themselves made of cut stone, the wing-walls in brick masonry without impediment below the outlets, or with the sills of the chambers in rear horizontal, and with no fall in the channels below for a distance of at least 10 feet, under the penalty before prescribed, in addition to the stoppage of the defective outlets until they are rectified. The guards of the river ought to report to the engineer of the delegation all deficiencies they may detect, with the needful proofs, so that the delegation may proceed effectively against parties neglecting or contravening their orders. The period of one month is granted for the purpose of bringing the defective outlets into conformity

with this rule, and of preparing them for survey by the engineer of the delegation.

8. The gates or sluices of all outlets ought to be kept invariably well secured by catches (*gattelli*), in such manner as that they cannot be raised beyond certain fixed limits. These sluices ought also to be so constructed as that there shall be no waste of water by leakage beneath them, under a penalty of 40 *lire* (about 32 shillings) on each sluice, and for each contravention.

9. Under the same penalty, it is forbidden to keep private padlocks or common locks and keys; and the guards, on finding such locks, shall cause them to be broken, and shall denounce the contravention, noting, that in each of the aforesaid cases, they shall proceed to close the outlets whether large or small.

10. It is forbidden to move, to raise, to lower, to repair, to alter, or, in fact, to do anything whatever to change the state of the river, or the outlets, the dams, the sills, the mills, and their inlets, without a license in writing from the delegation, the provisions prescribed by which shall be rigidly observed, under a penalty of 230 *lire* (about £8).

11. Specifies some local arrangements of no general interest.

12. All proprietors of outlets, large or small, not provided with channels (*soratori*) for collecting and carrying to the river the waters remaining after the irrigation of the land has been effected, are enjoined to construct such channels within the space of one month, according to the existing rules, which will be explained to them by the engineer of the delegation, under the penalty of having all such outlets as are unprovided with the aforesaid channels immediately stopped. The chan-

nels shall be kept clear from all impediments, under the same penalty.

13. On all festival days, as well as on others when the mills are not at work, the millers shall keep the gates and escapes of their mills open, so that the water may have its natural and free course, under a penalty as above in case of contravention.

14. The provision in the new statutes against millers irrigating more than 5 *pertiche* of land (about three-fourths of an acre) above the inlets of their mills, shall be enforced, under a penalty, for each contravention, of 115 *lire*, to be appropriated in the manner formerly specified (two-thirds to the delegation treasury, and one-third to the informer).

15. Whoever shall be discovered to have irrigated with, or to have had in any way on his lands, the waters of the Olona, in violation of the regulations, shall incur, for each offence, a fine of 115 *lire* (about £4), if the extent of land watered shall exceed 5 *pertiche*, and of 18.42 *lire* when it shall be less.

16. Prohibits fishing in the Olona without license, under a penalty of 46 *lire* for each offence; and killing the fish with lime, or other poisonous matter, under double this amount.

17. Any one using, impeding, or changing the course of old or new springs, whose waters flow into the river, shall incur a penalty of 460.51 *lire* (about £16), to be distributed in the manner formerly described.

18. Prohibits the soaking of flax in the river, or the throwing of any matter into it likely to interfere with its free course, under a penalty of 115 *lire*.

19. In accordance with the new statutes and regulations, no proprietor of land along the Olona shall be permitted to contract the channel of the river by esta-

blishing plantations, or brushwood, or stones. The channel shall be maintained with a breadth of at least 20 feet, with the banks clear of every kind of impediment, in terms of the existing regulations, and under the penalty specified in the preceding article, or under others adapted to the circumstances of each case.

20. Water from the outlets, destined for irrigation, can be granted to brickmakers and others for the use of their works, only under the written license of the delegation, the provisions mentioned in which shall be minutely observed, under a penalty of 115 *lire* for each offence.

21. When more than one person may be concerned in the various offences above specified, the prescribed penalties shall be imposed on each of the offenders, who shall be liable also for all legal expenses whatsoever.

22. Whoever becomes possessed of rights to the water of the Olona, under the dispositions of a last will, or by agreements between living parties, or in any way ceases to possess such rights, shall be bound, within the period of two months from the publication of the present regulation, to describe, under their proper heads in the register of the Olona, the manner in which these rights have been acquired or lost. In all time to come, the same obligation shall rest upon all parties acquiring or losing rights to the water, who shall be bound to register these within two months; and in case of contravention, the offender shall be fined one *lire* on every crown of the estimated value of the property or edifice not duly registered.

In cases of changes of property, the first proprietors, in the event of their failing to replace their own names by those of their successors, shall be held responsible, without farther notice, for all taxes or other burdens attached to the properties, according to the provisions of

Art. 28 of the I. and R. decree of the 10th February 1809.

23. In inflicting fines, the delegation shall proceed according to the provisions of the disciplinary regulation for the river Olona, to be submitted for the approval of the superior authority.

24. Whoever shall presume to offend, by word or deed, the delegates, the engineers, the chancellor, and the guards of the said river, shall be punished according to the terms of the penal code of the kingdom.

The delegation reserves to itself the power of publishing such supplementary provisions as are in conformity with the spirit of the present regulation, always, however, subject to approval by the superior authority.

The present shall be published fer general information, and affixed in the usual places throughout all the lands adjacent to the Olona.

From the Office of the river Olona, at Milan, on the 11*th May* 1812.

The Lambro is another of the smaller streams of the Milanese, which, as I have stated in greater detail in Part II., irrigates a considerable extent of land to the north-eastward of Milan. From its source in the hilly region near Como, to its junction with the canal Martesana, near Crescenzago, and from thence to the Po, it is under the administrative control of an association organised similarly to that of the Olona.* The regulations by which its administrative details are conducted, date from between the

* I am not perfectly certain on this point, as some of the documents connected with the administration of the river would seem to indicate that this was exercised more immediately by the Direction-General of Public Works. It is a point of no great importance; for whether, in analogy with all similar cases, the administration is vested in an association of proprietors, or by exception in a government office, the edicts above given show the details of management.

middle and the close of the last century. In 1832, two special edicts were republished by the Austrian government, one dated the 26th July 1756; the other, the 20th December 1782; and by these the interior economy of the river is at present regulated. The provisions of these edicts are given in the following translation :—

"*River Lambro.*

"All the arrangements relative to the river Lambro are included in the two following edicts, republished in 1832, under the authority of the I. and R. government, as conveyed in its despatch dated 9th November of that year :—

"1756, *July* 26.

"The numerous disorders which exist along the entire course of the river Lambro, from its origin in the lakes of Alserio and Pusiano, to its junction with the Po, having attracted the attention of the magistracy of the state of Milan, in consequence of the inconveniences and injuries at once to the royal treasury, and to public and private interests, which they have caused, most especially in the deficiency of water so frequently occurring, and traceable to them, and particularly as affecting the supply of the canal Martesana :

"The said magistracy, with the view of remedying such inconveniences, has judged it expedient—leaving in full force all former proclamations, especially such as affect the royalties (*regali*) of the waters—to publish the present edict :—

"Whereby, in the first place, it is forbidden to every person, of every grade or condition, without exception, to divert the water of the river Lambro from its proper course. No one shall employ it for the irrigation of arable land or meadows without the appropriate permis-

sion, and license by privilege or royal grant, under a penalty of three hundred crowns, of which two-thirds shall belong to the royal treasury, and the remaining third to the guards of the river appointed for its protection, whose testimony, with that of one credible witness, shall be sufficient to warrant proceedings against offenders.

"All parties enjoying the use of water from the Lambro, are warned against taking more than is secured to them by their respective privileges, grants, and rights, on pain of being proceeded against, not only for damages to the extent of the value of the water improperly taken in time past, but to entire deprivation of the water, and other penalties prescribed in this edict; their outlets shall be closed, and the evidence of the guards, or any other parties reporting the offence, supported by a single witness, shall be deemed sufficient for conviction.

"It is forbidden to millers, or other parties possessing mills on the river Lambro, to retain or check the water in any way, or under any pretext whatsoever. When the mills are not at work, the escapes shall be left open during the entire period of stoppage. Such mills as do not possess proper escapes, shall be provided with the same within eight days after the publication of the present edict, so that the water may flow freely into the bed of the river. These provisions shall be observed, under a penalty of one hundred crowns, to be applied as above described.

"Whoever, possessing the right to establish outlets or channels for the extraction of water from the Lambro, may have allowed the same to become broken or out of repair, shall be bound to place them in good condition within one month after the publication of this edict, under the appropriate license of the magistracy, who will determine, according to the circumstances of each case, whether an inspection by the engineer or other official of the tri-

bunal be necessary, or simply the assistance of the guard (*camparo*). If the repairs are not executed within the time specified, they shall immediately afterwards be effected under the orders of the magistracy, and at the expense of the recusants.

"Within fifteen days after the publication of this edict, all breaches in the embankments of the river or its branches shall be closed and repaired, so as to prevent any wastage of water, under a penalty of one hundred crowns, to be applied as formerly provided. Parties on whose lands such breaches occur, shall be held responsible for the repairs under the penalty above mentioned, which shall also be enforced against all on whose lands such breaches may occur in future. These shall be repaired by the agents of the magistracy, at the expense of the offending parties.

"It is forbidden to establish dams, or to construct works of any kind whatever, either across the bed or along the banks of the river, without the special permission of the magistracy, under a penalty of two hundred crowns for each offence. The water shall be allowed to flow freely, for the benefit of irrigators at lower levels, and particularly for the increase of the supply in the canal Martesana.

"It is forbidden to fish in the Lambro, or to destroy the fish with lime or other substance, under a penalty of two hundred crowns, unless special licenses are granted by the magistracy.*

"All parties using the water of the Lambro are enjoined to obey the orders of the guards appointed to watch over the execution of the present edict, under a penalty

* The great care of the fish in all the rivers and canals will be appreciated when it is borne in mind how important they are as articles of food in a Catholic country.

of one hundred crowns, which may be increased at the will of the magistracy.

"Two guardians are appointed for the river, one having charge from the source, near the lakes Alserio and Pusiano, throughout the entire district of Crescenzago, and the other from this latter point to the junction of the Lambro with the Po. They are enjoined to watch carefully over the execution of the present and all pre-existing regulations, to secure for the river all the water that of right appertains to it, and to report all infractions of the orders of the magistracy, on pain of removal, and such other punishment as may appear due.

"No one shall be permitted to persevere in present or past abuses, on the plea of neglect, tolerance, or carelessness of the public agents. No such plea shall be accepted from any one in mitigation of punishment for breach of these orders; and the magistracy reserves to itself the power of taking whatever steps may seem to it best in each case, saving always such rights as may be vested in the royal treasury.

"This notification shall be published, not only in this city of Milan, but in the towns of Monza and Melegnano, and in the adjoining districts."

"MILAN, 20*th December* 1782.

"His royal highness the governor having taken into serious consideration the disorders existing in the administration of the river Lambro, has enjoined the magistracy to furnish to the guards such instructions as seem best calculated to bring these abuses to a close. The following are therefore prescribed :—

"Retaining in full force all pre-existing regulations, and especially that under date the 26th July 1756, the guard of the Lambro residing at Monza is enjoined to visit

annually, before the 25th of March, the springs commonly called *teste* (the heads), by which the river is fed, with the view of ascertaining that all these are well cleared, and that they really supply the entire quantity of water which could be obtained from them. All parties interested in such supply should depute persons to accompany the *camparo* during the said visits, to concert and arrange with him regarding the nature and extent of the necessary clearances, or of such other works as may be required for the efficiency of the heads. The guard should report the whole of these proceedings for the information of the magistracy.

"Having satisfied themselves of the correctness of this report, the magistracy shall order the execution of the repairs, the expense of which shall be recovered from the employers of the water in proportion to their respective interests in the same. In addition to these expenses for works, a fair remuneration shall be fixed, at the discretion of the magistracy, for the assistance given by the guard.

"It is forbidden for the future to throw earth or rubbish, or other matter, into the river, or to extract sand, except from collections of deposit; and in removing these, care shall be taken not to derange the natural level of the river. Excavations or ditches for the collection of sand or gravel are absolutely prohibited.

"If a necessity should arise for clearing earthy materials from the bed of the stream, parties desirous of doing so should communicate with the guard, who will satisfy himself that the work contemplated can cause no damage either to the river itself or to the adjoining properties. In the event of new work being undertaken, reference should be made to the magistracy, who will prescribe such conditions as may appear most appropriate in each case.

"Various tortuosities of the Lambro being caused by

trees falling into the bed, or by spurs which throw the force of the stream on the opposite bank, to the injury of the proprietors of land there from the corrosion which is the consequence, the guard ought immediately to intimate to the proprietors of such trees or spurs that they must remove them within three days, otherwise they shall be removed by the guard himself, and all expenses for work or damage shall be at the charge of the proprietor.

"The trunks and roots of trees which come down the river in time of flood shall be removed by the guard; and as it is impossible to know whose property they are, they shall be granted to him as a reward for his exertions in removing them.

"The soaking of flax in the river being injurious to the fish, it is absolutely prohibited; but parties may carry on the process each in their own channels, and the guard should at once report any infraction of this order to the magistracy.

"To prevent any affectation of ignorance, his royal highness orders this edict to be affixed in all public places along the river, and enjoins all parties to obey the agents of the magistracy."

The foregoing will, I think, be sufficient to illustrate the internal economy of the irrigating associations of the Milanese. I might add more, but I do not find that the details contain matter of sufficient practical interest to justify my doing so. The examples given do not indicate a very exact system of measurement or distribution; and as no specific means are taken to insure the observance of the precise terms of the grants, we may safely conclude that mere injunctions to the proprietors will not, in case of temptation, be much attended to. In fact, the antiquity of the rights to the water of these rivers prevents any

minute interference with them; and as the Government has always been foiled in its efforts to introduce exact measurements, it seems now to have arrived at the conviction that it had best confine itself to general police and protective measures, such as have just been illustrated. It will be seen at once from the terms of these that the due enforcement of the system hinges entirely on the personal probity and conscientiousness of the *campari* or guards; and it must be admitted that the temptations to which they are exposed are excessive. It is not, therefore, to be wondered at that police regulations, however sternly expressed, do not generally produce any great moral effect. I believe, however, that the administration is always best when the proprietors themselves can be made its agents; the value of the water is in truth so great that every man becomes more or less a police officer; and as his interests are directly concerned, his vigilance has the best possible stimulant: hence one of the main causes of the value of that associative principle which pervades the irrigation system of Lombardy. When in vigorous and healthy action, it is a far more powerful conservator than the most elaborate establishment depending solely on the Government, though supported by the severest of edicts and proclamations.

It may perhaps be interesting to illustrate the manner in which this principle is applied in practice, by giving here the rules for the elections of the representatives of the great canal Muzza, which is administered by two congregations—one called the congregation of the Muzza Milanese, for the province of Milan; the other that of the Muzza Lodigiana, for the province of Lodi. These rules were published on the 11th of April 1817, and are to the following effect:—*

* From BRUSCHETTI'S *Storia dei Projetti per l'Irrigazione del Milanese*, p. 416.

"1. Within a period of not more than three months from the date of the publication of this notification, all the employers of the water of the Muzza shall be assembled in convocation. Under the term 'employers' (*utenti*) are included all those who obtain water from outlets, great or small, and having attested titles either in their own names or in the names of others.

"2. For all matters which concern the employers of the outlets included in the congregation of the Muzza Lodigiana, the assemblies shall be held at the official residences of the royal chancellors of land revenue (*nel luogo e officio de' regi cancellieri del censo*) of the respective districts of the province of Lodi, and with the aid and in the offices of the same functionaries in the districts of the province of Milan, for all that may concern the employers forming the congregation of the Muzza Milanese.

"3. The royal chancellors of land revenue may hold assemblies of the employers of one or more outlets on the same day.

"4. The object of the assemblies, with the day, the hour, and the place where they are to be held, should be published in a printed form, similar to that hereto annexed, at least eight days before the day of meeting, and circulated in all the communes where outlets exist, and also in the chief towns of the districts and provinces.

"The royal chancellors of the different districts should enter into communication with each other, so as to arrange conveniently for the publication of the summonses; and they will request the I. I. R. R. Delegations to make the necessary notifications in the chief places of the provinces.

"5. The publication of the summonses, in the manner above described, shall have the force of a legal act of convocation for all parties who may not be domiciled in the communes where the outlets belonging to them exist.

"6. Employers have the power of deputing a procurator, furnished with a special mandate, to represent them in the assemblies, whether as individuals or corporations.

"7. The military, wards, minors, women, and corporations, or public and private administrative bodies, shall be represented by their respective guardians, tutors, curators, procurators, and legitimate administrators.

"8. The employers of each outlet, legitimately convoked as above prescribed, shall proceed to the election of one deputy to represent the body of the said employers in the respective congregations of the Muzza. This deputy shall have power to vote, in the congregation to which he belongs, for a representative of the entire congregation; and to the two representatives thus elected—one for the province of Milan, the other for the province of Lodi—shall be committed full powers to arrange with a commission nominated by the Government, all details connected with the use of the waters of the canal, whether as regards the regulation and modulation of the irrigation outlets, or the employment of the surplus waters, (*acque colatizie*), or the equitable increase of the annual payments for the taxed outlets.

"9. It is forbidden to propose in the convocation any other subject of discussion, or to deliberate on the same, under any title whatsoever.

"10. The election of the deputy shall be made by ballot, (*a scrutinio segreto*). Two individuals shall first be nominated from each separate body of employers—that is, from among the employers of each outlet—by the votes of the entire assembly. From among those thus selected, the four who are found to have the greatest number of votes shall proceed to another ballot, and the individual having the majority in this, shall be the representative of the congregation.

"11. The convocation is legitimately constituted, when its number is not less than one-third of the total number of employers.

"12. Absentees shall be held to have concurred in the election of the deputy, and shall be bound by all that is done or established under the provisions of the present notification.

"13. If from want of the above specified number, the employers of each outlet are unable to proceed to the election of a deputy, this election shall be made by the respective congregations, whether of Milan or Lodi, within the space of five days.

"14. No convocation shall be made in the case of outlets having only one employer, whether an individual or a corporation, or a public or private administration; nor in the case of any outlets whose employers are less than six in number; in the first case, the legitimate deputy is the sole employer, either in his own person, or when corporations or administrations are concerned, by means of the legal administrators; in the second case, the largest employer is the legitimate representative of the body.

"15. The acts and proceedings of the convocations of employers are to be recorded by the royal chancellors who assist at them, and are signed by the said chancellors and two of the parties present.

"16. As the royal chancellors hold the convocations in succession, they shall transmit the acts and proceedings of the same to the respective provincial delegations, who, having collected the whole, shall forward them to the government commission.

"17. The commission, on finding them all in order, shall communicate with the respective congregations of Lodi and Milan.

"18. The deputies elected according to the foregoing

form, and the single and principal employers having the attributes of delegates, according to Art. 14, shall unite themselves to their respective ordinary congregations, and with them shall form one deliberate body.

"19. The congregations and special deputies, thus united, shall meet at the chief place of the province on the invitation of a royal deputy, and in accordance with instructions which will be given by the Government. The royal deputy shall always be present, and shall discharge the duties of president.

"20. The congregations and deputies shall be summoned by letters addressed to the members individually, by the I. R. delegates, at least fifteen days before the time fixed for the meeting. These letters shall specify the day, the hour, the place, and the general object of the meeting."

21 to 29, being merely repetitions of the rules previously given for the election of the deputies in each congregation, applied to similar elections in the united bodies of congregations and deputies, I do not consider it necessary to give them. Their object is to obtain the nomination of two representatives of the entire canal, whose arrangements with the royal commission, on all matters connected with the interior economy of irrigation, should be binding on the whole body of employers in both the provinces of Milan and Lodi.

I must add, that this effort to organise anew the police and administration of the Muzza was not very successful, as, according to Bruschetti, the employers of the canal, distrusting the Government, held back from the convocations, so that the legal numbers required to form a quorum were rarely present. It seems always to have been in this passively resisting manner that reforms projected by the Government have been defeated; and in the present

instance, though the introduction of some arbitrary changes was tried, the practical result was, that the ancient system remained but little disturbed. I have given the rules for the elections, simply as illustrations of the system, which, in cases of accord between government and the proprietors of land and water, and with modifications of detail, adapted to local peculiarities, has been found to meet the wants aud wishes of both parties.

In the abstract of the provisions of the laws of the 20th April 1804, and the 20th May 1806, an article (No. 20) prescribes, that "in such districts as have relations with foreign powers, the existing conventions and customs shall continue in force." The special object of this article was to maintain in vigour the rules which had been established by the treaty of Ostiglia, dated the 25th June 1764, between the governments of Austria and Venice, for the regulation and distribution of the waters in the conterminous provinces of Mantua and Verona. As these rules continue to operate up to the present time, and, as having been the work of a commission of the most eminent Lombardian and Venetian hydraulicians of the time, contain a considerable amount of interesting information on the various points to which they refer, I think it worth while to give a translation of them in full when the matter merits it, and in abstract when it is less important.

The definitive treaty above referred to was preceded by various regulations sanctioned by the imperial and republican governments, and affecting the river Tartaro and its affluents, which are among the chief sources of water for irrigation in the two provinces. It was about the beginning of the seventeenth century that the first serious efforts were made to eradicate the abuses which had crept into the irrigation system, and which at that period forced themselves specially on public notice. It

was found that old outlets were enlarged without authority; that new ones were similarly established; that constant robberies of water were systematically practised; and that, by the use of temporary dams or other means, proprietors possessed of no just title irrigated their land during the night, to the injury of the legitimate owners of the water; that grants for irrigation of meadows were made use of in establishing rice-lands, which accordingly spread to an undue extent, and absorbed so much of the supply as to deteriorate all other irrigated products. Severe edicts were accordingly published in 1602, 1603, 1607, and 1610, against these malpractices; and from this time to the beginning of the eighteenth century, the governments made constant, though not very successful, efforts to enforce them. The violations, however, continued to exist, in spite of all efforts to the contrary, and about 1715, their extent threatened to embroil the two powers. Some years later, it was finally agreed between the Austrian and Venetian governments, to nominate plenipotentiaries, assisted by men of skill and honour, "to propose a clear and precise regulation, which might remedy, once for all, the abuses in existence on the Tartaro and its affluents, in such a manner as to insure tranquillity among the river population, and to preserve peace between the two states." As a result of the deliberations of this body, the first treaty of Ostiglia was signed on the 20th April 1750, and was followed by the declaration of Roveredo in 1753. The provisions of both these acts were finally embodied in the treaty of the 25th of June 1764.

As preparatory to the adoption of the necessary regulations, the engineers of the two states met at Ostiglia, and afterwards personally examined the various rivers, canals, and water-courses. They classified the different abuses

they found in existence, and their attention was specially given to the determination of the rice-lands in the two provinces; for it was found that the double influence of profit and imperfect superintendence had led to these being increased much beyond what was considered their just limits. In the first treaty in 1750-53, certain clearly-defined areas had been prescribed for the rice-lands in each province, and all cultivation of this kind in excess of these was at once suppressed. The general principle adopted by the commission was, that "the water flowing in its natural channels should have perfectly free course for the benefit of all the adjoining proprietors, and that consequently no works should be allowed which interfered with this freedom—securing, however, to all mills already in existence, sufficient fall to enable them to work effectively; while at the same time regulations should be enforced to insure the return of the whole of the water thus diverted, to the natural channel of the river, canal, or water-course." Various detailed arrangements were carried into effect; numerous outlets, not possessed of just titles, were closed; others were reduced in dimensions; and statements, in minute detail, of all authorised outlets and areas of irrigation, were prepared for future reference. The progress of the new system of administration was gradual; the commissioners continued to publish, from time to time, Appendices to the original treaty, amounting in all to ten, the last of which, dated the 19th June 1765, is naturally the most perfect of the whole. It is from this that I give the following summary of the administrative arrangements in Mantua and Verona:—*

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* The Appendix No. 10 is given at full length in Part II. of CANTALUPI's *Collection of Laws and Regulations*; and from this my translation is made.

Tenth Appendix to the Treaty of Ostiglia.

Art. I. The Tartaro and its affluents, including also the canals of Pozzolo and Molinella, shall be cleared every five years, in the manner and under the superintendence of the engineers appointed by the respective governments. The expense of these repairs shall be borne by the associations of proprietors interested, or by individuals for such portions as are assigned to them in the present treaty, or as may belong to them by right of ancient possession. (Certain portions of the Tartaro, the Tartarello, and various smaller streams, are placed under charge of the association of the Tartaro, which will superintend and pay for all needful clearances; the canal "Il Cavo" is similarly placed in charge of two private individuals. Various other canals and streams are disposed of in like manner, the details possessing no special interest.)

Art. II. Continues the details of the work to be done in clearing the various streams and canals, and of the associations or individuals at whose expense such works are to be executed.

Art III. All the aforesaid excavations shall be renewed at intervals of five years, as well in the province of Mantua as in that of Verona. When the engineers deputed by the governments to inspect the canals shall find any work neglected, they are authorised to execute the same at the expense of those by whom it ought originally to have been done.

Art IV. Such partial repairs as the Tartaro and its affluents may require shall also be executed annually. (Minute details of the nature of these repairs, and of the parties by whom the expense of them is to be defrayed, are given here.) The number of annual clearances varies

from one to four, according to local circumstances; and the periods are during the first fifteen days of April, if there is but one repair; and in May, July, August, or October, if there are more; the object being to close the canals only at such times, and in such manner, as shall be least injurious to the crops.

Art V. Continues the above-noted class of details.

Art. VI. All these clearances, whether in the province of Mantua or that of Verona, shall be superintended by the engineers in charge of the waters; and should these officers have reason to consider the work badly executed, they are empowered to rectify all errors and imperfections at the expense of those parties whose duty it was to have completed them effectively in the first instance.

Art. VII. Except when deficiency of supply in the river may permit it, the level of water at the head of the canal of Pozzolo shall always be maintained at a height of two Veronese inches (about 3¼ English inches) above the fixed mark established there to indicate the full supply.

During the season of irrigation, the left escape of the mills of Gazo shall always be kept open. On the other hand, all the sluices and locks on the Tartaro and its affluents, both Mantuan and Veronese, shall remain closed during the same season. (Specific dates for the closing and opening of various sluices belonging to private parties follow; but there is not much of general interest in the details, further than that each sluice must be provided with strong gates, having lock and key attached; the keys of all on each side of the river being intrusted to the provincial inspectors of the respective provinces, to be by them retained from the 25th of March to the 8th of September of each year, with the obligation of opening the gates in all times of flood.)

Art. VIII. Secures to the Marchese Ferdinando

Cavriani the power of constructing a temporary dam or spur, of certain specified dimensions, to be maintained in the river-bed from the 10th of October to the 10th of March of each year, but to be carefully removed on the latter date by the proprietor, so that the full supply of the river may be available for summer irrigation. If it is not removed on the date specified, the engineers, or the proprietors below, are authorised to destroy it at the expense of the marchese.

Art. IX. Prescribes very strict rules for the proprietors of mills, requiring them to refrain from constructing any dams across the streams, or in any way whatever obstructing the free course of the waters for irrigation ; to keep the escapes of their mills always open, so that the water may return to the rivers, allowing them only in cases of great scarcity of water to close the gates of the existing dams across the streams, until a quantity of water sufficient for the movement of one wheel has been forced into the mill channel : they are not permitted to take more water than this until the rivers have returned to their ordinary levels.

Art. X. Proprietors of land, bordering on the Tartaro and its affluents, are prohibited from breaking or in any way injuring the banks, and from growing trees in positions injurious to the same, or to the free course of the water. Any of the latter which may exist shall be cut down within eight days after the publication of the present regulation, after which time the agents of the Government shall remove them at the expense of the owners, confiscating the wood for the benefit of the governing authority. In future, the river proprietors shall be bound to maintain in good order such portions of the embankments as lie within the limits of their respective properties.

Art. XI. Prohibits any proceedings destructive of the fish in the Tartaro and its affluents.

Art. XII. The outlets, escapes, the retaining dams, the weirs, and all other forms of regulators by which water is drawn from the Tartaro and its affluents, whether Mantuan or Veronese, being modulated according to the terms of the treaty; the heights of sluices and locks being similarly fixed, the culverts, the bridge canals, the drainage channels being previously regulated; the levels of the various springs and water-courses, both public and private, being established; and the directions, breadths, and positions of the same water-courses being duly arranged, the banks being repaired, the spurs and retaining dams removed, and all the channels of both provinces being placed in a state of efficiency, it is absolutely forbidden to change the order of things thus established in any way whatsoever, under penalty of the loss of all right to water, which shall be forfeited in such cases for the benefit of the governing authority. Should the offender possess no rights to water, such process shall be commenced against him, and such punishment inflicted upon him, as is specified at the close of this proclamation.

Whoever may have occasion to alter any of the outlets or works above referred to, shall apply to the governments of the respective provinces for the necessary authority. The changes in question shall be affected, in terms of the treaty, under the superintendence of the engineers deputed by the governments. The positions of the water-courses, whether Mantuan or Veronese, shall on no account be altered under pain of forfeiture, and the surplus-waters shall be disposed of only in the manner prescribed by the treaty.

Art. XIII. When lands are too high to be benefited by the water at its ordinary levels, the proprietors shall

not be permitted to raise it by artificial works other than those permitted by the treaty. Such lands must remain unirrigated, and their proprietors are enjoined to submit patiently to this inevitable result of the elevated position of their estates.

Art. XIV. The employers of the waters of the Tartaro, and its affluents in Mantua and Verona, are required to limit their consumption of water, and their areas of irrigation, according to the tables attached to the treaty, under penalty of confiscation of their rights for the benefit of the governing authorities. To insure the exact execution of this provision, it is permitted to any employer to demand an *ex officio* survey of the rice-irrigation in any district where excess is suspected, on condition that the expense shall be defrayed by the offending party, if an excess over the area fixed by the *conti giusti* of Gazo is found to exist, or, in the contrary case, by the party at whose instance the survey was undertaken. And in order that all may know the rule by which such surveys shall be conducted, it is hereby declared, that in measuring the extent of rice-land, an allowance of 5 per cent on the total area shall always be made on account of land occupied by water-courses, banks, or other works required for irrigation. When the excess is not more than 5 per cent on the area fixed for each proprietor in the official tables, no contravention of the present rule can be established. When several irrigators employ the same outlet, the area of irrigation in each separate property must be measured as above prescribed, so that in case of contravention the actual offender may thus be discovered.

Art. XV. No one shall usurp the use of the water belonging to another. In case of usurpation, summary proceedings shall be taken to indemnify the injured party,

and the competent tribunals shall hold the usurpation to be proved, when any proprietor has derived benefit from water belonging to another, unless he can show clearly that such benefit was purely accidental, and was not due to any active measures of his own.

Art. XVI. It is forbidden to open ditches in the vicinity of the embankments of the Tartaro or its affluents, in which the waters of the rivers might collect; and such of these as have been already opened shall be promptly filled in again. It is also forbidden to excavate for new springs within an area of 50 *pertiche* (about 325 feet of the Tartaro and its affluents; and should such springs be exposed, either by manual labour, or by natural movement of the water itself, they shall not be used for irrigation, under all the penalties above described. (Certain exceptions to this general rule follow, but it is not necessary to detail them.)

Art. XVII. Irrigators who have legitimate titles to water their lands possess no rights to the surplus waters, (*colaticcie*), which shall be allowed to flow freely to the rivers for the benefit of proprietors below. The surplus waters are subjected to the same rules as the springs situated within 50 *pertiche* of the rivers (325 feet).

Art. XVIII. Refers to some private agreements concerning rights of fishing.

Art. XIX. Imposes on the chamber of Verona the repairs of certain masonry works which have been injured by time and floods.

Art. XX. Refers all injured parties to the governments of the two provinces, and promises speedy redress of grievances.

Art. XXI. Appoints certain parties on behalf of each province to inspect annually the Tartaro and its affluents, and to take measures in communication with the engineers

or other officers duly nominated by the two governments for maintaining in full force all the provisions of the treaty.

Art. XXII. Appoints two professional men to visit the works whenever necessary, and to execute all repairs. In the event of disagreement, provides for the nomination of other professional men (*periti*).

Art. XXIII. As it is the will of the respective sovereign powers that full and entire obedience shall be enforced to all the provisions of the present proclamation, they resolve that all offenders against the terms of this treaty, in addition to repairing all damages caused by their transgression, shall farther be subjected to such pecuniary or corporeal punishments as may seem right to the respective governments; and if the offenders have rights to the enjoyment of water, they shall be deprived of these, in addition to such other penalties as may be imposed upon them, and their outlets shall be placed at the disposal of the governing authority. And if the offenders should be unable to pay the fines inflicted on them, or to repair the damages they have caused, they shall be imprisoned for such periods as seem just in each case. All proceedings under the present act shall be summary and free from the ordinary formalities of judicial proceedings, each government communicating to the other the steps taken against offenders.

To the end that no one may allege ignorance of the present edict, it shall be published and affixed in all usual places throughout the two provinces, with a view to its full and inviolable execution.

The 19th day of June 1765.

The administrative and police details contained in the preceding articles, have special reference to the rivers

common to the two provinces of Mantua and Verona. The management of the streams and canals belonging exclusively to Mantua, is regulated by an edict of the Austrian government, dated the 24th December 1781, which continues in full force at the present time. This document is the last which it seems to me necessary to give in illustration of the present section, and I will translate it *in extenso* only when the matter is new or of special interest.

Edict regulating the use and distribution of water in the province of Mantua for irrigation or hydraulic works.

Art. I. Forbids the damming up, directly or indirectly, of water-courses of any class or kind, or the alteration of any escapes, weirs, or channels, in such manner as that the water may be turned to the use of the offending party, or to the injury of others, under a penalty for each offence of 2000 *lire* (upwards of £60!) of which half shall be granted to the informer. Failing payment of the fine, the offender shall be sentenced to imprisonment with hard labour for one year.

Art. II. The chief sources of injury to the banks, and of obstruction to the free course of the waters, are trees, underwood, or bushes of any kind. It is forbidden to plant these on the banks of the public canals and rivers, and such as exist shall be cleared away within twenty days from the publication of this edict. After this time the wood shall be cut down by the public officers, and sold for the general benefit of the associations of the rivers and canals.

Art. III. The lines of piles placed in the channels to facilitate fishing cause serious damage. These shall all be removed and sold for the general benefit; and, in future, whoever replaces such works shall be subject to a

fine of 100 *lire* (about £3), whereof one-half shall be granted to the informer.

Art. IV. The proprietors of mills and their work-people are forbidden to raise the water, by any means whatever, above the levels either already fixed, or to be fixed hereafter. During floods, they shall be careful to open the escapes, so as to prevent damage. Each offence against this rule shall subject the offender to a fine of 200 *lire* (about £6).

Art V. All proprietors of water-courses shall be bound to maintain them in thorough repair, so that no water may escape from them into the public roads, or in any way cause damage to other parties, under a penalty for each offence of 200 *lire*, in addition to payment of all expenses for injuries done.

Art. VI. All employers of water shall obtain the quantities defined and fixed by their titles and grants. Forfeiture of all right to water shall follow the illegitimate alteration or extension of the prescribed areas of irrigation.

Art. VII. Like forfeiture shall be the consequence of any improper interference with any of the various kinds of works on the canals. When a change in these is desired, application shall be made to the magistracy of water for the province, who will order the proper steps to be taken.

Art. VIII. Employers of water who have irrigated the areas assigned to them, shall be bound to allow the surplus waters to flow off freely for the benefit of lower-lying lands. To this end, every proprietor shall be bound to establish drainage channels for the collection of the surplus waters; and neglect in doing so shall entail forfeiture of all right to water from the respective canals.

Art. IX. Orders that periodical inspections of the

canals be made by the prefect or vice-prefect of the province, so as to insure observance of the provisions of the edict.

Art. X. It being a common but mischievous practice for parties to carry water to lands so placed that the surplus waters are entirely lost, it is ordered that every landed proprietor shall cause to be made, at his own expense, a map of his property, on which the irrigable land shall be shown in its true dimensions, and with its heights above the sources of supply of water clearly exhibited; also, all the water-courses, culverts, roads or principal canals, aqueducts, weirs, locks, and every other kind of works, shall be plainly shown. This map shall be preserved as a record in the office of the magistracy of waters, and shall be corrected from time to time, as changes are duly sanctioned by the proper authorities. Neglect of the present order shall be punished by loss of rights to the water.

Art. XI. No changes of any kind shall be effected but under the orders of the magistracy, executed by the prefect or vice-prefect.

Art. XII. The conservators of the different irrigating associations are enjoined to watch over the efficiency of the works under their charge. They shall make an annual inspection, and submit a report on the works to the congregations of their respective associations, indicating all the repairs or new buildings required, and estimating the probable expense thereof. The visits shall be made during the first days of the month of February, and the congregation shall be held about the middle of the same month. By which means all needful repairs may be completed about the middle of April, when the demand for water arises.

Art. XIII. The conservators shall be careful to clear

the canal-beds of all water-plants and weeds, causing them to be dug out by the roots for some distance from the water's edge, throwing the refuse clear of the embankments. If necessary, clearances of this class shall be executed three times a-year.

Art. XIV. All parties are enjoined to receive, and execute with promptitude and good-will, the orders of the conservators of the different associations. Disobedience shall be punished by a fine for each offence of 200 *lire*, (about £6), which shall be increased at the discretion of the magistracy; if any offence be committed a second time by the same party, it shall be lawful to proceed against him, under the provisions of the municipal laws.

Art. XV. The annual tax shall be paid by all parties within the time prescribed by the congregations, and defaulters shall be proceeded against without further notice.

Art. XVI. Parties not possessing legal titles to irrigation shall not use, even to the smallest extent, the waters of the canal. The first offence against this rule shall be punished by a fine of 1000 *lire* (about £30), with forfeiture of all the irrigated produce, and compensation to parties injured by the misappropriation of the waters. The second offence shall be punished by the *confiscation* of the land illegitimately irrigated.

Art. XVII. We reserve to Ourselves the right to make grants of water for irrigation; and We hereby declare, that if it should come to our knowledge that arable or forest or meadow lands have been broken up for the purpose of creating rice-fields, in excess of those fixed by considerations of public police, and duly limited thereby, the grants thus abused shall be revoked; and we give notice that we will not in future allow any new rice-cultivation to be established, until it has been proved to our entire satisfac-

tion that the lands to be so employed are all in such low-lying localities as to be unfitted for use under any less injurious kind of cultivation.

Art. XVIII. In making grants, we do not thereby vest in the grantee the right of property in the water, but only the right to use it either in irrigation or for hydraulic works. The right of property shall remain as heretofore among the rights appertaining to the crown.

Art. XIX. In all grants for the use of water, whencesoever derived, from *colature* or from works, we maintain in full force the provisions of existing treaties, in consideration of the benefits hitherto derived from their observance.

Art. XX. Every grant shall be expressed in terms of the *quadretto Veronese*, by which is meant that quantity of water which flows through a square outlet for irrigation, having each side equal to 1 Veronese foot, and a head of pressure equal to 2 Veronese inches—(*i. e.* in English measure, the side of the square equal to 13.362, and the head to 2.23 inches).

Art. XXI. To guide grantees in their specifications of the volumes of water necessary for their lands, it appears from experiments made with the *quadretto*, as above defined, that the water furnished by it is sufficient for the primary irrigation of 80 *campi Veronesi* employed in rice cultivation. (The *campo Veronese* is equal to very nearly nine-tenths of an English acre; hence the area above specified is equal to 72 English acres.) The first surplus waters (*prime scolaticce*) are sufficient for the irrigation of 40 *campi* (36 acres), and the second (*seconde scolaticce*) for 20 *campi* (18 acres), in addition to the primary area. (I may remark on these data, in passing, that the value of the *quadretto Veronese*, in English measure, is very nearly 5 cubic feet per second. The total

area, including primary, secondary, and tertiary irrigation, which, on the present authority, this volume is competent to water, equals 144 English acres—the land being under rice. Hence the effective area of irrigation for 1 cubic foot per second is 28.8 acres.)

When the water is employed for meadow lands, the *quadretto* is sufficient for the irrigation of 25 *campi* (22.5 acres) in twenty-four hours, or for 175 *campi* (157.5 acres) in a rotation of seven days; and the same proportion holds good according to the larger or smaller extent of land, or to the variation of the periods of rotation. (It therefore appears, that for meadow-land 1 cubic foot of water is sufficient for the irrigation of 31.5 acres in a rotation of seven days, or for 63 acres in the more usual period of fourteen days.)

Art. XXII. The price of such a *quadretto* of water (and proportionally for one-half, one-fourth, one-sixth, according to the wants of the grantee) shall be 44,400 *lire* (£1480 nearly), when it is to be used on lands already in great part cultivated; but in case of the lands being generally uncultivated, the price shall be only 39,000 *lire* (£1300 nearly). These sums shall be paid by the different consumers of the water, according to the tariff hereunto annexed. (From these data, it appears that, in the province of Mantua, proprietors of lands fully cultivated pay for water at the rate of £296 per cubic foot per second, and proprietors of inferior lands at the rate of £260 for the same quantity. Payment of these sums in capital gives a perpetual right to the use of the water. The prices do not vary much from those in the Milanese and elsewhere.)

Art. XXIII. For all rice and corn mills (excepting the floating mills on the Po, the Oglio, and other rivers, for which the annual rent has been fixed in wheat by the

magisterial chamber), the price of water shall be 10,000 *lire* (about £333) for each wheel supplied with a constant stream of water, and for others in a like proportion, according to the time during which they respectively receive water sufficient for their effective action—(*i. e.*, if they can work only for half the year, they pay half the above sum, and so on for other periods).

Art. XXIV. For all other hydraulic works designed for manufactures, the gratuitous use of the necessary volume of water shall be granted for fifteen years. After the lapse of this period, the proprietors shall be bound to pay an annual sum of only 100 *lire* (a little more than £3), with the power of redeeming the same by a single payment of the capital, calculated at the rate of four per cent.

Art. XXV. Every purchaser of water is permitted, without limitation of time, to pay the price of the quantity of water granted to him, either in capital, as above established, or in lieu thereof by an annual sum, calculated at the rate of four per cent on the capital value, commencing from the date of the contract. To facilitate the payment in capital by parties of limited means, it is permitted to liquidate the total amount in four equal instalments (annual, I presume, though no specific intervals as mentioned. Under the operation of this rule, the annual payment for 1 cubic foot of water in the province of Mantua would range from £10 for inferior, to £12 for superior lands. As this volume irrigates annually 28.8 acres of rice land, and 63 of meadow, the cost per acre is about 8s. 4s. for the former, and 3s. 9d. for the latter).

Art. XXVI. To insure the reform of abuses, and to protect the interests of the royal treasury, all employers of water shall be bound to submit their titles, after due notice, to a deputation of officers, which from time to time

shall visit the canals, with full authority to investigate and dispose of all cases brought before them, according to their judgment.

Art. XXVII. The guards (*campari*) and police (*birri*) shall use all diligence in protecting the interests intrusted to them, and shall denounce all contraventions to the secretary to the magistracy of waters. In cases of neglect, the offending party shall be declared incapable of again serving the State; but if collusion or participation be established, he shall be sentenced to imprisonment with hard labour for a period not exceeding three years, according to the decision of the magisterial chamber.

Art. XXVIII. The magisterial chamber shall determine all farther provisions necessary to the execution of our laws, and shall decide on all matters connected with the waters of the province.

Art. XXIX. enjoins general obedience to the edict.

The tariff referred to in Art. XXII. is as below. I have shown the approximate values of the sums given in English money. I say approximate values, because there are various *lire* in use, and the edict does not specify any particular one. By assuming the value of a *lira* to be 8d., however, we are exact enough for practical purposes.

[TARIFF

TARIFF of PRICES of WATER for IRRIGATION per QUADRETTO VERONESE, in the Province of MANTUA.

	For land in great part cultivated.	For land very partially, or not at all cultivated.
The first employer, . .	£845 14 0	£742 17 4
The second employer, for the first surplus waters, ...	422 17 0	371 8 8
The third employer, for the second surplus waters, . . .	211 9 0	185 14 0
Total per *quadretto*, equal to 5 cubic feet per second, . . .	£1480 0 0	£1300 0 0

To supply the means of comparing these results with others in the former sections of this report, I annex the values of a cubic foot per second, as deduced from the preceding table :—

	Value of one cubic foot per second of water for first-class land.	Value of one cubic foot of water for second-class land.
For the first employer, . .	£169 2 9	£148 11 6
For the second do., . . .	84 4 6	74 5 9
For the third do., . . .	42 12 9	37 2 9
	£296 0 0	£260 0 0

From the details I have now given of the interior management and police of the rivers Olona and Lambro in the province of Milan, of the Canal Muzza in the provinces of Milan and Lodi, of the Tartaro and its

affluents in Mantua and Verona, and lastly, of the streams and canals specially belonging to the former of these two provinces, a sufficiently clear idea will, I hope, be found of the general organisation of the Irrigation System throughout Lombardy. Perhaps a summary of its main outlines, divested of detail, will be the most appropriate conclusion to the present section which I can give.

The controlling and directing authority in all matters connected with hydraulic works is vested in the direction-general of public constructions, established in Milan, and presided over by a director-general, always an engineer of distinguished reputation.* Attached to this office are chiefs of the different departments of waters, roads, public buildings, &c., some of whom make periodical visits of inspection to the provinces, while others remain permanently at head-quarters. In subordination to the direction-general, the chief of the canal department regulates the interior economy of the great government canals, through the agency of the local superintendents and guards; and in those districts where no government canals exist, references to the direction-general are made through the government engineers in each province. Through these channels the Government exercises its controlling authority over that immense series of local associations for irrigation, which is spread over the whole surface of the irrigated regions of Lower Lombardy. Each of these associations is self-administering—is represented by an elective council, in which is vested the power of nominating one or more engineers and subordinate agents, as the extent of the works or the area of irrigation may render necessary—is competent to impose taxes to the extent

* The present director-general is Signor Elia Lombardini, of whose high attainments and unvarying kindness I had repeated proofs during my residence in Milan.

necessary for maintaining the works, to determine all interior regulations, and to act freely within the limits prescribed by the laws, and under the general superintendence of the superior administrative authorities. By these associations the great mass of the civil engineers, so numerous in the country, is maintained in constant and profitable employment; and it is unquestionably to the energetic operation of the principle on which they are founded, in combining effort and giving command of capital far beyond what isolated individuals could have done, that the wonderful development of the Irrigation System of Lombardy is to be traced. In thus collecting the proprietors of water into groups, and giving to each group its fairly elected representative body, its president and executive council, as it were, there is a simplicity and efficiency which highly recommends the system; and I am glad to think that, long before we had any knowledge of its having been sanctioned by centuries of practical experience in Italy, it had been introduced independently into our canal administration in Northern India, with the happiest possible results. It has been established as the *sole* principle on which water shall be granted from the grand Ganges canal. The two millions of cultivators who will ultimately depend on this great arterial line and its branches for their irrigation, will be linked together in a series of such bodies as I have above described; and I trust it may be considered expedient to introduce the representative system into the organisation of these bodies; for I am sure it will be found the most effective means, at once of stimulating the development of irrigation, and of facilitating the police duties, and the administration of the works, as vested in the officers of the Government. A principle which is found to pervade the irrigation systems of Italy, France, and Spain, and is admitted to work

satisfactorily in all, may advantageously be introduced into that of Northern India, where, too, the habits and feelings of the people, as illustrated in their village associations and ordinary social customs, prove that such a principle is already familiar to, and sanctioned by them.*

SECTION LAST.

SANITARY REGULATIONS.

However much the highest authorities on the subject may differ as to the true nature of that malaria which manifests itself by its influence on health in marshy districts, there are certain circumstances under which all agree that it is inevitably to be looked for. When tracts of country covered with vegetable matter, subject to periodic decay, are alternately wet and dry—when, in addition to this alternation, the moist and semi-putrescent soil is acted on by the powerful stimulus of a temperature occasionally almost tropical, all experience shows that miasmatous influence, productive of fevers and other forms of disease, is generated. It does not concern me now to inquire

* The *Punchayat*, literally implying a Council of Five, but applied as a generic term in practice, is the favourite arbitration system in this part of India. The *Lumberdars*, or headmen of the village communities, are the representatives of the entire population. We have now the associative principle fully recognised in our irrigation system, but the organisation of the associations is still very imperfect. The formation of a *Punchayat* for each chief water-course (*Rajbuha*) would greatly simplify the dealings of the canal officers with the cultivators, especially when these come to be numbered by hundreds of thousands in each executive division. The *Congregations* of Northern Italy, the *Syndicates* of Southern France, the *Juntas General and Ordinary* of Spain, are all thus represented by executive councils having relations with the government officers. The organisation of associations for irrigation is comparatively modern in France; but in Spain it dates from a very remote epoch—so remote

what the nature of this influence is; in fact, I am well aware that it has hitherto eluded the most careful investigations, and is to be recognised only by its effects on the animal frame. I advert to one series of conditions as above, under which it is known to be developed, because these are present in certain forms of irrigated cultivation; and it is to the measures which the government of Lombardy has seen it expedient to adopt, to counteract, as far as possible, the prejudicial results of these kinds of culture, that I propose now to direct my attention.

The species of culture in Northern Italy to which objections have been taken on sanitary grounds, are those of rice, *marcite* or constantly flooded winter-meadows, and common periodically-irrigated meadows. The opposition to the former has been decidedly more vigorous and continuous than to the latter. Public opinion is almost unanimous as to the unhealthiness of rice cultivation, and concerns itself about palliations for it, in the hope rather of reducing it to a minimum, than of removing it altogether. There is by no means the same general agreement regarding the insalubrity of winter, or common meadow, irrigation; and I shall have to show hereafter some fair grounds for believing that these kinds of culture are not unhealthy ones. At present I will give a rapid

as to astound one! The earliest credible date of existing regulations is, however, 1239; though we are gravely assured that the royal canal of Moncada, to which they apply, was originally constructed during the year 850, after the deluge! The chronology of canals and the *chateaux en Espagne*, have, I fear, foundations of the same aërial character! Fables apart, however, the juntas of irrigation date *certainly* from the reign of James I., king of Arragon, or from the beginning of the 13th century; and *probably* their first formation was earlier, as the Moors constructed large and important canals during their sovereignty in Spain, leaving permanent records thereof in the technology of irrigation, in which a great number of terms are palpably Arabic. There is a great deal of most interesting information on the irrigation canals of Spain, in a work by M. Joubert de Passa, of which a copy is now before me. It is entitled *Travels in Spain, or Researches on Irrigation*, &c. 2 vols. Paris, 1823.

historical sketch of the progress of sanitary legislation in Lombardy, which exhibits curious ebbs and flows of opinion on the subject, worthy of brief consideration.

The introduction of rice cultivation into Europe is attributed to the Moors of Spain,* and, so far as is known, took place about the close of the thirteenth century, at which period a large number of the canals of irrigation in the country were constructed. After the conquest of Valencia, the Spanish government continued the cultivation for some time : but on account of the numerous complaints against its insalubrity, they were compelled to prohibit it altogether. This prohibition was confirmed by the king Don Pedro in 1342, and in 1403 was made applicable to the entire kingdom. Since that period, the culture of rice has been successively tolerated, sanctioned, or forbidden, in constantly varying succession, though at this moment it exists to a considerable extent. Its fate in Italy has been very similar. Introduced into the Venetian provinces about the beginning of the fifteenth century, it extended rapidly through the marshy tracts so common in this region. The great swamps of Verona and Mantua, useless for every other species of culture, offered a profitable field for rice; in these it was early established, and has always continued to be of great importance. Its progress to the westward was slow, and it was not until the middle of the sixteenth century that the rice cultivation of the Milanese became of sufficient extent to attract public attention to its sanitary relations. Its development thus kept pace with the progress of that great system of irrigation canals which had been perfected at this same time.

The earliest sanitary regulation on record bears date the 4th of September 1575. By this, rice cultivation is

* *Voyage en Espagne*, par M. JOUBERT DE PASSA, vol. ii. p. 267.

restricted to certain areas in each district, and is altogether prohibited within certain distances of inhabited places. Two reasons are assigned for these measures: 1st, To maintain the proper ratio between rice and other kinds of cultivation, which probably may be taken as an indication of the rapidity with which the former was extending; and 2d, The numerous complaints which had been received against its insalubrity. The principles of restricting the area of the culture, and prohibiting it in the vicinity of human habitations, which thus appear in the very first regulation published, will hereafter be found to pervade the entire course of sanitary legislation, and, with variations of detail, to be in fact the only principles recognised in the system. In 1583, the duke of Terranova, then governor of Milan, prohibited absolutely the establishment of rice-fields in marshy places throughout the whole territory of Milan, which then included the provinces of Novara and the Lumellina. As may be supposed, such a regulation caused extreme dissatisfaction. Proprietors of such lands, who before had derived great profit from them, found their revenues suddenly annihilated, and opposition to the order was vigorous and decided. In 1593 a new regulation was issued, by which the above prohibition was modified, and the culture was forbidden within a radius of 6 miles round Milan, and of 5 miles round every other town. Considering the area of the provinces commanding a full supply of water, and the number of towns of various sizes scattered throughout them, the land thus withdrawn from rice cultivation was of serious extent, and the regulation was still the cause of much bad feeling. On the part of the landed proprietors it was urged that no distinct proofs had been obtained as to the *degree* in which rice cultivation was injurious to health; that the injury itself was matter rather of pre-

sumption than of proof; and that it was most unjust for the Government to interfere with the free exercise of the right of property on grounds still so indeterminate. It was therefore held that, until experiments and investigations, calculated to establish clearly the facts of the case, had been undertaken, it was mischievous both to public and private interests to enforce prohibitions so extensive and severe. The government of the day gave a certain amount of consideration to these complaints; and though the prohibition was not removed as the landowners wished, its limits were restricted. The prescribed distance for Milan was fixed at 4 miles, and for other towns at 3 miles;* but in practice the terms were very imperfectly observed. A little later, the Government established a regular system of sale for permissions to form rice-lands, and authority to do so was granted by a body of officers of health, on payment at first of a certain fixed sum, and subsequently without any payment at all. In 1600, the Spanish government farther relaxed the terms of the prohibition, by allowing the distances to be measured from the centres of the towns, and not from the exterior walls, or from the terminations of connected buildings, as was previously the rule. In 1630, a frightful pestilence devastated the province of Milan, and led to renewed complaints against the rice-lands. Many years passed by, however, without any decided movement being made to give effect to these, though in the meanwhile inquiries had been instituted, in which nearly the entire medical faculty of the country are related to have taken a part. The results were so far in favour of the rice cultivators, that in 1661, and on the evidence above referred to, the Government came to the

* There is but little difference between the English and Italian miles above referred to. The common Italian mile is 1982, and the small one is 1818 yards in length. The distances above given are in the former.

conclusion that the injurious influence of the culture on the public health was open to question, but that there could be no question whatever as to the mischievous effect of the restrictive system on the agriculture of the country. Willing, however, to give sanitary considerations the benefit of the doubt that existed, it was resolved to maintain the existing prohibitions, only with the substitution of the small mile of 1818 yards for the large one of 1982. The distance for Milan was therefore reduced from 7928 to 7272 yards, and that for other towns from 5946 to 5454 yards. It was further decided that these measures should be made from the centres, and not from the exteriors of the towns. It cannot, however, be said that the Government was much in earnest in enforcing its own laws on this subject. The tide of opinion, in fact, flowed fairly at this time in favour of the agricultural interest. In December 1668, a new edict farther diminished the distances to 5454 yards for Milan, and 3636 for the other towns. The execution of this edict was preceded by a new examination of physicians and engineers, the tendency of whose opinions is sufficiently indicated by the modifications just referred to. The parties generally opposing the extension of the culture of rice were the municipal authorities of the towns, naturally anxious for the salubrity of the places under their charge. The entire body of the country proprietors was opposed in this respect to the towns, and the Government doubtless found it an ungrateful task to mediate between the disputants. A reaction against the proprietors, who had hitherto the superiority in the contest, occurred in 1694, when the king of Spain, as sovereign of Lombardy, restored the ancient distances of 4 large miles for Milan, and 3 for the other towns, further requiring the distances to be measured, not from the centres, but from the exterior

limits of the inhabited places. These provisions appear to have continued in force, nominally at least, for nearly a century; but as in all times past, the execution of them was little, if at all, attended to.

We are now arrived at the period when the existing sanitary regulations had their origin. They are based, like the general legislation of irrigation, on an act of Napoleon, bearing date the 3d February 1809; and though some of the provisions of this have been modified, I think it will be interesting to give the regulation in full, as an illustration of the manner in which this question has recently been treated in Lombardy.

"ITALIAN REGULATION of the 3d February 1809, relative to RICE-LANDS, to MARCITE MEADOWS, and to IRRIGATED MEADOWS.

"TITLE I.—*Of Rice-Lands.*

"1. In future no one shall be permitted to convert land into rice-fields, without the special permission of the prefect of the department in which the land is situated.

"2. Offenders shall be punished by a fine equal to twice the value of the annual produce of the land formed into rice-fields without permission. The proprietor equally with the tenant shall be subjected to the above fine, unless the former can prove his ignorance of the act of contravention.

"3. Permission to establish new rice-fields can be granted by the prefects only under the following limitations, viz.,—

"(1*st.*) That the fields so established shall be at a distance from the capital of the kingdom, of at least 8000 metres, (4.97, or say 5 English miles).

"(2*d*.) That they shall be distant from communes of the first class and fortified places, at least 5000 metres, (3.10, or in round numbers, 3 English miles).

"(3*d*.) That they shall be distant from communes of the second class, at least 2000 metres, (1.24, or 1¼ English mile).

"(4*th*.) And finally, that they shall be distant from communes of the third class, at least 500 metres, (0.31 English mile, or about 530 yards).

"4. The distances prescribed in the foregoing article shall be measured in right lines from the exterior walls; in the case of walled places, and in that of open places, from the last house which forms part of the aggregate habitations of these places.

"5. The rice-fields now existing within the distance prescribed for the capital shall be adapted for other cultivation, within the space of three years from the publication of the present decree, under the penalty specified in Art. 2.

"6. With reference to the other communes of the 1st, 2d, and 3d classes, proprietors of rice-lands now existing within the prohibited limits are permitted to continue the cultivation of them until otherwise ordered. They are forbidden, however, to increase and extend their rice cultivation without the permission prescribed by Art. 1.

"7. We reserve the right to determine farther regarding the above prohibitions, and the periods of their execution, after we are in possession of the opinions of the municipal councils of the respective communes, and of the councils-general of the departments on the points referred to.

"The minister of the interior is requested to direct the prefects to submit the present question for the consideration of the municipal and general councils.

"The deliberations shall be held during the next session, and the decisions shall be immediately forwarded by the prefects, with their own opinions attached.

TITLE II.—*Of Marcite and Irrigated Meadows.*

"8. It is forbidden to establish constantly or periodically irrigated meadows in the interiors of inhabited places.

"9. By the close of the present year all such meadows shall be adapted to other kinds of cultivation.

"10. It is equally forbidden to establish such meadows in the vicinity of communes of the first class or fortified places, without the permission of the prefect.

"11. This permission shall be granted only on the following conditions:—

"(1*st.*) With respect to the capital, the irrigated lands shall be distant 1000 metres at least, (0.62 English mile, or about 1100 yards).

"(2*d.*) With respect to the communes of the first class and fortified places, the lands shall be distant 500 metres at least, (about 530 yards).

"The distances shall be measured as for rice-lands.

"12. Before the close of the year 1811, all permanently or temporarily irrigated meadows within the distance of 1000 metres from the capital, and of 500 metres from first-class communes and fortified places, shall be employed for other kinds of cultivation.

"13. The provisions in Art. 2 shall be applicable to offenders against Articles 8, 9, 10, and 12.

"14. The fines received for violations of the present decree shall be levied by the receivers-general of finance, and shall be paid into the royal treasury.

"15. The ministers of the interior and finance are charged with the execution of the present decree, in all

"The expense of the survey shall be borne by the applicant.

"5. The claim and the survey being submitted to the communal council, and duly considered by them in relation to the public health, they shall proceed to vote; and in recording their decision, they are required to note whether rice cultivation has ever before been introduced into their commune or not. If it has been so introduced, the total area of rice-fields previously existing in the commune must be specified.

"6. The district commissaries shall forward, without delay, the original demands, surveys, and decisions, to their respective provincial delegations, annexing details of any circumstances likely to guide the superior authorities in forming their opinions on each case.

"7. The provincial delegations having carefully examined all the documents connected with each case, and having recorded their opinions, shall prepare a general tabular statement of the whole, to be submitted to the I. R. Government not later than the month of December of the same year."

From the data now given, it would appear that in Lombardy the sanitary legislation of irrigation is in a very imperfect state; that *practically* it affects rice cultivation alone, by establishing certain rules for regulating its extension, the application of which, in each particular case, is determined by the will of the Government. The distances fixed by the law of the 3d February 1809 are generally neglected; and I do not think I shall make any serious error if I state, that at the present moment the agriculture of irrigation, though nominally restricted by the existing regulations already quoted, is, under the system by which these regulations are administered, *really*

and *practically* free to extend itself, according to the wishes, the wants, or the supposed interests of the proprietors of the waters.

I am concerned at present rather with things as they are, than with things as they ought to be; and I will therefore postpone the remarks that suggest themselves on the state of affairs described above, until the experience of Piedmont has been examined. Meanwhile, I may very briefly give some details, which seem to me to justify the non-interference of the Government in the case of *marcite* and common meadow irrigation. Why, indeed, the latter should ever have been interfered with at all, seems to me difficult to understand. The meadows are watered once a fortnight usually. The quantity of water thrown upon them is equal in its effects to a heavy shower of rain, but scarcely more. Means of efficient drainage are invariably established under the best of guarantees—the guarantee of self-interest in the valuable surplus waters, or *colature*. Stagnation of the water, even for a very limited time, is rigidly guarded against, as an imperfection most injurious to the crop. With such provisions and precautions, it is impossible to conceive that irrigation can be mischievous to health; and the idea that it is so seems to be universally abandoned.

As regards the winter meadows, which are continually under water, there seems greater room for doubt; but even with these, the balance of evidence appears to be in favour of leaving them free to expand at the will of the community. In the work on winter meadows by Signor Berra, to which I have before had occasion to refer, there is a very elaborate discussion on the sanitary relations of this species of culture. There is no necessity for my giving this in detail; but I think an abstract of it will not be devoid of interest.

"The fundamental principle," says Signor Berra, "of this kind of cultivation is, that the water shall be in perpetual movement; consequently, any stagnation whatever is not only mischievous, but is a violation of the first rule to be observed. Farther, it must be borne in mind, that winter meadows exist only during the cold season, when the temperature is low, and the tendency to putrefaction limited—the vegetation never decays—it is in continual and vigorous growth. How is it possible, then, to rank our *marcite* meadows, in reference to their influence on the public health, with marshes of stagnant water full of decaying animal or vegetable matters? I have no idea of asserting that the climate of Lower, is equal in salubrity to that of Upper, Lombardy. I admit that the natives of the latter are more robust, better able to work, and more willing to do so, than those of the former; but this difference seems to me to arise from the physical, moral, and agricultural peculiarities of the two regions, and not solely from the fact that, while the inhabitants of the one employ irrigation, those of the other do not. The atmosphere of the irrigated region is unquestionably more humid than that of the hilly tracts. The working population in the former are mere labourers; in the latter, they are to a large extent small proprietors, and, consequently, may be supposed to work better, and live better, than the others. Yet, on comparing the statistics of health in the two regions, the difference between them is exceedingly small; so small, indeed, as to be easily accounted for by the simple fact, that one class breathes the air of the hills, the other of the plains, where malarious places quite unconnected with irrigation do certainly exist." To illustrate this statement, Signor Berra has prepared a series of statistical tables from the official returns made to the Government, which I do not give *in extenso*, as they

are bulky, but to the general results of which it may be interesting to advert. I may state, that I find these statistics, though referring to the years 1816-21, quoted in the very latest discussions on the present subject which have come under my notice, and I therefore conclude that their authority in Italy is considerable.

The comparison between the salubrity of irrigated and non-irrigated districts is made by means of two tables, which are numbered II. and III. in the series. In No. III. are recorded the marriages, births, and deaths, throughout five irrigated districts of the province of Milan during six years; and in No. II. the same data are given for the same time in ten unirrigated districts. The causes and numbers of deaths at different ages are minutely specified; and from these the following general inferences may be drawn.

The mean population of the irrigated districts amounted to 69,363 souls; and the total number of deaths in six years, to 15,675. The population of the unirrigated districts was 228,002; and the total deaths, 49,335. The mean annual deaths in the former amount, therefore, to 2612.5; and in the latter, to 8222.5; or, in other terms, while the annual mortality in the irrigated districts is 1 in 26.6, it is only 1 in 27.7 in the unirrigated districts.* The difference, therefore, according to Signor Berra's data, amounts to only 0.14 per cent. "This excess," he remarks, "though very small in itself, is not be attributed to the existence of winter meadows, but to the circumstance that in district XI. of Milan, and XII. of Melignano, there is a considerable amount of rice cultivation, which, in its effect on the public health, is unquestionably prejudicial."† I may only farther note, that as regards

* The per-centage of deaths in the irrigated districts is 3.75; and in the unirrigated, 3.61; the difference being, as above given, 0.14.

† I am always grateful for *facts* in examining this question; and I may note

longevity, the tables show that, of 1000 persons dying in the irrigated districts, 222, and in the unirrigated districts, 263, are recorded as having passed fifty years of age; while in the former there were 83, and in the latter 111, of every 1000, above 65 years of age at their deaths.

It is to be observed that, in the irrigated districts whence the foregoing data have been procured, there exist tracts of marsh land and rice culture, which complicate the results; but, making due allowance for these, the general conclusion arrived at, from the statistical details, is, that districts where meadow irrigation, periodic in summer, and continued in winter only, is practised, the public health is so little affected by it as to justify the Government in refraining from all direct interference with its progressive development. There is a farther reason for this, in the fact that the actual amount of *marcite* cultivation, though very important, is very limited in area as compared with the total surface of the country. The entire amount throughout Lombardy probably does not exceed from 15 to 20 square miles; and considering all the physical circumstances under which this extent of irrigation is practised, its being the only irrigation of the season, and that season the winter, I certainly think it is wise to leave the cultivators entirely to themselves; and I am therefore glad that the existing legislation, as affecting these meadows, is virtually dead.

In carrying into effect a comprehensive scheme of agricultural irrigation, in a region whose physical features are favourable for it, it is perfectly possible so to combine the primary object of irrigation with general and local drainage as to secure an improvement, rather than to

here, that in the province of Pavia, where rice is more abundant than in any other part of the country, the annual mortality of the population exceeds, by 8 in 1000, that of the province of Milan.—BERRA, p. 39.

cause a deterioration, of the climate of the country. The government of India is placed at present in this position. It is introducing irrigation into vast tracts of country, admirably adapted in all topographical and physical details to benefit by it; and as the comprehensive plans in progress of execution include, as an essential part, the drainage of all such tracts as are at present in a marshy state, and therefore injurious to the public health, there is every reason to hope that malarious influence will be materially decreased so soon as these various works come into operation. I believe the scheme of sanitary improvement, as linked with irrigation, may be carried still farther. There is not a large town within the reach of the great canals now in progress—whether in the region between the rivers Ganges and Jumna, or throughout the populous districts of the Punjaub, destined to be hereafter the Lombardy of India—which might not be thoroughly cleansed and drained through the immediate agency of their waters. Looking to the fall of the country, there are very few of those towns which might not be traversed by a running stream, derived from and again rejoining the nearest canal. The waters of this, after having been made available for all purposes of cleaning and draining, might be again utilised for irrigation, at a sufficient distance to prevent any bad effects; and thus town and country would participate in the advantages of the general system. It is in this way that the waters of some of the great canals of Lombardy have been made subservient to sanitary purposes in towns; and I cannot better close the present section, than by giving, as an illustration of this system, the regulations under which the town drainage of Milan is effected by water derived from the canal Martesana.

In the historical details connected with the rivers of

the Milanese, formerly given, I have adverted to that knot of streams formed at Milan by the junction of the Nerone, the Sevese, the Olona, &c. As in London, so in Milan, the rivers which once traversed or encompassed the old city no longer see the light of day, but, walled in within culverts and drains, they form the main sewerage lines of the modern town.

The city of Milan, as regards its drainage, may be regarded as consisting of an inner circle, of which the circumference is formed by the canal Sevese, and of two exterior concentric zones, the first bounded by the Sevese and the Naviglio Interno, the second by the Naviglio Interno and the town walls. The inner circle includes the most ancient part of the city, and is supposed to mark its limits during the classic period; the Naviglio Interno, as may be remembered, indicates the area of the Milan of the middle ages, while the exterior line of all marks the extent of the modern city. The canal or river Sevese is the principal drainage line, and is entirely covered in. The Naviglio Interno receives a large amount of drainage also; but being, as is known, an open and navigable line, it is less directly subservient to purposes of this kind. The total supply of water in the Sevese, obtained by three outlets from the canal Martesana, amounts to 45 cubic feet per second. The whole of the minor sewers are so connected with the main line as that they can be scoured into it by the use of this volume of water; and these various small streams are reunited in a common channel, which, on passing outside the city, assumes the name of the Vettabbia, to which I have had frequent occasion to refer. The details under which this system of sewerage is managed are interesting; and if town drainage be linked to the irrigation system of India, as I think it may be, they may also be useful. I there-

fore give a translation of the regulations under which the association of the Sevese carries on its usual functions: it is a comparatively recent enactment, bearing date the 29th of December 1836.*

"TITLE I.—*Organisation of the Society.*

"1. The houses and all other property whatsoever within the limits of the city, which enjoy the advantage of drainage into the canal of the Sevese, whether directly or through branches derived from the same, shall form a 'district.'

"2. All the holders (whether individuals or corporations) of property situated within the perimeter of the said district shall form an association.

"3. The parties forming the association shall nominate by ballot the delegates for the congregation, on the day and at the place which shall be indicated by the I. R. Provincial Delegation. If the number in attendance does not exceed one-third of the total number of the proprietors forming the association, the delegates shall be selected by those actually present from a triplicate list composed of the largest proprietors.

"5. The delegates shall be renewed every two years, to the extent and in the manner provided for by the decree of the 20th May 1806. The provincial delegation shall nominate the new delegates from a list submitted by the congregation of the society, being careful to observe the rule of seniority as regards the retiring delegates. Retiring delegates may be re-elected indefinitely. In case of the death or retirement of one or more delegates, their places shall be supplied by ballot, as above provided for.

* My translation is made from the copy of the regulation given in vol. ii. of the *Manuale delle Leggi Regolamente e Discipline*, &c. of ANTONIO CANTALUPI, p. 111.

"6. The congregation shall be composed of twelve delegates and a president, who shall hold his office for one year. All the delegates first elected shall succeed to the presidency in rotation, regulating the succession by the number of votes each received at the election. The rule of simple seniority to be observed in all subsequent cases.

"7. The congregation shall meet at the house of the president once in two months. The provincial delegation, or the president of the congregation, have the power of summoning extraordinary meetings. The president shall execute the decisions of the congregation, unless members be specially nominated for this purpose.

"8. The ordinary duties of the congregation shall be to superintend the drainage canals and their respective escapes as maintained by the association, to cause all necessary repairs to be executed, and to issue demands for the expenses incurred. The president shall communicate to the engineer the orders of the congregation, in case of filtration, breaches of drains, or other accidents.

"9. The congregation shall decide in all cases by plurality of votes.

"10. The proceedings shall not be legal unless four delegates, exclusive of the president, are present.

"11. For the consideration of new projects, the association shall nominate twelve extraordinary delegates, in the manner indicated by Art. 4.

"12. The union of the old and new delegates shall form an extraordinary congregation, which shall decide on the new works and the means of executing them.

"13. Provides for the submission of the decision of the extraordinary congregation for the approval of the Government, on the receipt of which the execution of the works shall be intrusted to the ordinary congregation.

TITLE II.— *Officers of the Association, and their Duties.*

"14. The congregation shall be assisted by the following officers, at the annexed rate of pay :—

		Aust. lire.		
1. An executive engineer,	at	300,*	. about	£12
2. An accountant, .	...	150,	. ...	6
3. A clerk, . .	...	200,	. ...	9
4. An executive assistant,	...	530,	. ...	21
5. A Chancellor, .	...	200,	. ...	9

6. A Treasurer, who shall receive, 1st, An allowance of 5 per cent on all sums not paid within the period fixed by the congregation for settlement of the annual tax; 2d, An allowance of 5½ per cent on the entire income of the congregation, whether ordinary or extraordinary.

"15. The executive engineer shall be bound to superintend, with the aid of the assistant, all the measures necessary for the regulation of the drainage; to prepare the contracts for clearance and repairs, and to verify the execution of the same; to make all inspections which may be ordered by the congregation; and, in a word, to give to this body the full benefit of his advice under all such circumstances. These shall be considered his ordinary duties. The extraordinary duties shall be to prepare, at the close of every period of nine years, the plans of all the inlets for each house separately, and the proportionate rate to be paid by each proprietor; to execute the projects of new works for the association, and to superintend the construction of the same. For all such duties the engineer shall receive extra pay, according to the scale in force at the time for the remuneration of the engineers of communes.

"16. The accountant shall keep the accounts of the

* I presume these are monthly rates; but the original document enters into no details on this point.

annual expenditure of the association, shall issue the orders for payment, and shall submit to the congregation an annual account-current of receipts and disbursements.

"17. The clerk shall keep all the records, and shall direct all details of internal management.

"18. The assistant shall exercise the immediate executive duties connected with the works, effecting the clearances, and regulating the supply, by careful attention to the escapes, especially in times of flood. He shall also watch over the exact observance of the orders of the congregation, and shall report to the engineer all breaches thereof.

"19. The chancellor shall assist at all meetings of the congregation, shall record its proceedings, and shall register the same in a convenient form. He shall also act as secretary and legal counsel, keeping all the legal papers belonging to the association.

"20. As regards the treasurer—

"(*a.*) He shall keep by him the distribution list of assessment decided on by the congregation, and shall levy the sums specified therein from the parties by whom they are due, on warrants signed by the president, one delegate, and the accountant. The assessment shall be levied under the rules in force for recovering the direct taxes.

"(*b.*) Prescribes certain technical rules for recovery of the assessment, of no general interest.

"(*c.*) The treasurer shall furnish sufficient security, shall be nominated by the congregation, and shall act under its responsibility.

"(*d.*) He shall be debited with the entire amount of each rate, five days after it has become due, whether he has received it or not.

"(*e.*) In case of opposition to payment of the assessment by one or more proprietors, the treasurer has no

power to postpone his demand unless he receive a special order to that effect from the congregation or the provincial delegation.

"(*f.*) In case of objections to the proceedings of the congregation being found unjustifiable by the superior authorities, the treasurer shall levy the amount of all expenses incurred for visits of the engineer, &c., as contemplated in Art. 26, in addition to the ordinary assessment due by the objecting parties.

"(*g.*) Requires the treasurer to keep his accounts after a specified fashion.

"(*h.*) Gives the congregation full power over the amount of cash in the treasury.

"21. Authorises the congregation to nominate a messenger.

"TITLE III.—*Formation of the List of Contributors, and Regulations connected therewith.*

"22. The assessment for the expenses of drainage shall be made at intervals of nine years. At the close of each period the engineer of the congregation shall inspect each house having its drains connected with the Sevese. In the record of this visit he shall note the quantity and nature of the drains from each building, the extent of the frontage, with such other points as may be useful, procuring the countersignature of the proprietors or their legal representatives to indicate their concurrence. These latter parties shall be informed that, if they do not attend, the inspection report of the engineer will be acted on without farther reference to them.

"23. Dissatisfied proprietors may demand a new inspection on paying for the same.

"24. If a proprietor wishes to remove any part of the drainage lines referred to in the engineer's report, he shall

submit a petition to that effect to the congregation, who will decide thereupon.

"25. Every proprietor who desires to avail himself directly or indirectly of the drainage channels of the Sevese, shall submit a petition to the congregation, who will depute their engineer to visit the spot.

"26. When any proprietor calls for a visit from the engineer of the congregation, except in cases of filtration or breach of the drains, he shall pay 12 Austrian *lire* (about 9s.) to the treasury.

"27. Requires notification of all changes of proprietorship to be made.

"28. Any person opening a new drain after the publication of this regulation, without due authority, shall incur a penalty equal to twice the amount of the assessment for nine years, in addition to payment of the ordinary charge for the drain. The penalty shall be levied within fourteen days after it has been imposed, unless the order of the congregation has been cancelled by the provincial delegation within the above-mentioned time.

"Drains not constructed according to the orders of the congregation shall be subject to a penalty equal in amount to one assessment for nine years.

"TITLE IV.—*Works connected with the Drainage Channels.*

"29. With the view of insuring the maintenance of the levels of the canals, profiles in stone shall be established at intervals of 340 yards, or less if necessary, on which shall be marked the true depths of the channels.

"30. The clearance of the canals shall be effected twice a-year, at the periods when the canal Martesana is laid dry.

"31. The repairs of the canals shall be executed from

time to time as required, the supply of water being previously stopped.

"32. The clearances shall be effected exclusively by contract. The repairs shall also be executed by contracts, at a specified rate for each special kind of work done.

"TITLE V.—*Distribution of the Expense, and Scale of Payments.*

"33. The estimate for the maintenance of the canals shall be founded on the experience of the preceding nine years, with such additions as the engineer of the congregation may consider necessary.

"34. The assessment shall be regulated according to the provisions of Title IV. of the regulation of 20th May 1806.

"35. The distribution of the amount of the assessment involves three separate elements: 1st, The amount of the estimate for the expenses of the nine years' period; 2d, The divisor of this sum found in the manner explained below; and, 3d, The unit of assessment which results from the division of the first element by the second.

"The divisor of the estimate, which serves to determine the unit of assessment, is obtained by considering each house to have a certain length in *metres*, according to its extent of frontage towards the canals, with the quantity and nature of the drains discharging into these.

"In this survey the houses are assessed in two separate classes: 1st, With reference to the drains, directly or indirectly, connecting them with the Sevese; and, 2d, With reference to their frontage.

"1*st. Assessment in Measure by Drains.*

	Length at which each shall be assessed.
(*a.*) Principal slaughter-house, . .	20 m. = 66 feet
(*b.*) Secondary slaughter-house, . .	15 ... = 49 ...

	Length at which each shall be assessed.
(*c.*) Dye-houses, cesspools, dairies, channels carrying the refuse of stables, and generally all premises not included in *a* and *b*, . . .	10 m. = 33 feet
(*d.*) The drainage of a stable for from one to four horses, . . .	5 ... = 16 ...
Do. do. from 4 to 8 do., . .	10 ... = 33 ...
Do. do. from 8 to 12 do., .	15 ... = 49 ...
And so on in the same proportion.	
(*e.*) The drainage of a family wash-house, A drain from a house occupied by several tenants shall be assessed at this rate for each tenant using it.	5 ... = 16 ...
(*f.*) The drainage of rain-water in courts,	3 ... = 10 ...
(*g.*) The same outside, . . .	2 ... = 6½ ...

"2d. *Assessment by Frontage, according to ancient custom.*

(*h.*) Frontage towards the main canal shall be assessed according to its actual extent, if the drain flows outside the house; but if underneath it, the assessments shall be on double the actual length of frontage.

(*i.*) Frontage on the small canals Vetra de' Cittadini and San Martino shall be assessed at two-thirds of its actual extent when the canal flows past the houses, but at twice this proportion if they are under them.

(*l.*) The banks draining into the canal called il Traverso di Porta Tosa, shall be assessed at one-fifth of two-thirds (or 2-15ths) of their actual extent.

(*m.*) The portions of the canals which cross the main and minor streets shall be assessed on two-fifths of their length when connected with the main line, and on 2-15ths thereof when discharged into the smaller branches.

(*n.*) The frontage of the civic buildings, and those on the Piazza del Castello, shall be assessed according to their actual length.

(*o.*) The bridge delle Pioppette shall be assessed according to its length.

(*p.*) The churches and parochial houses, inhabited by private parties, shall also be included in the distribution list, and assessed according to their actual frontage.

"The survey and measurement of all the houses comprised within the district having been made as above prescribed, the sum total of the frontages, and the lengths fixed for special drains, constitutes the divisor or second element for the distribution of the assessment.

"By dividing the total amount of the estimate for the expenses by the entire length subject to assessment, the quotient gives the unit, which, applied to each house as entered in the survey, admits of the distribution list being finally formed.

"36. On the tax being sanctioned by the superior authority, the distribution list shall be published for general information. The payment shall be made in three equal rates, and shall become due at the commencement of each triennial period, according to specific regulations to be determined by the congregation.

"37. The distribution list shall be kept by the treasurer, and shall be at all times open to inspection by the members of the association. An advertisement to this effect shall be published in the Gazette of Milan, and in this the date of payment of the first rate shall be intimated. Similar advertisements shall fix the dates on which the second and third rates become due. The congregation shall farther communicate to each member of the association the amount of his quota by an appropriate circular, but the non-receipt of such circular cannot be held to excuse delay of payment after the date fixed in the public advertisement.

"38. At the close of each period of nine years, the

congregation shall submit detailed accounts current to the provincial delegation, which shall have power to call for similar accounts at any intermediate time, should such a step seem expedient.

"TITLE VI.—*General Arrangements.*

"39. When the congregation considers it necessary to break up the arches or other parts of drains under houses, the proprietors shall be bound to give all practicable aid without claim for compensation. The congregation, however, shall be bound to restore the works to their original state, with as little delay and inconvenience to the house proprietors as possible. The latter ought, farther, to be very careful in keeping the drainage free from all impediments.

"40. Except in cases of unforeseen accidents, the congregation shall always notify to the municipal authorities their intention to open any of the drains under the public streets or roads.

"41. To prevent accidents, the parts of the streets under repair shall be inclosed within barricades, and lighted by lamps during the night.

"42. Repairs shall be executed with all possible despatch.

"43. The restoration of the roads and streets shall be effected at the expense of the congregation of the Sevese, and the repairs shall be inspected and approved of by the engineer of the municipality.

"44. Complaints against the proceedings of the congregation of the Sevese shall be heard and decided on by the provincial delegation, to which the congregation is subordinate, according to the terms of the decree of the 20th May 1806, which is the basis adopted by the

supreme authority in reorganising the congregation of the Sevese.

"MILAN, *the 29th December* 1836."

I can find no other materials connected with the sanitary administration of the canals in Lombardy which seem to me worth recording. It would lead me into a very large field, were I to enter upon the legislation of general drainage, land improvement, and protection of river embankments, which, in a country so profusely supplied with water, has branched out into very minute detail. But I must for the present, at any rate, postpone all discussion on these points, and be content in having given such information as I could collect on the single subject of irrigation, hoping that, though no doubt imperfect, it may not be altogether useless or uninteresting.

CHAPTER II.

LEGISLATION OF IRRIGATION IN PIEDMONT.*

SECTION I.

ON THE RIGHT OF PROPERTY IN WATER.

As in Lombardy, so in Piedmont, the right of property in all running water is reserved to the State. This reservation applies not merely to the larger class of rivers, but also to streams and torrents, the water of which can only be used under specific grants from the appointed agents of the government. A royal patent, under date the 29th of May 1817, which has still the force of law, regulates, in great detail, the manner and terms according to which such grants are to be made. The two first articles of this patent are to the following effect :—

"I. All the rivers and torrents of the State are royalties (*regali*), and by consequence they appertain to the royal domain.

* For the subsequent details of the legislation of irrigation in Piedmont, I have consulted the following works—"Codice civile per gli Stati di Sua Maesta il Re di Sardegna." "Codice Penale di Sardegna,"—Appendice, ii. Colombani. "Raccolta delle Provvisioni intorno le Acque, i Ponti e Strade del Piemonte :" Turin, 1845. "Giovanetti sur le Regime des Eaux." "Annali di Giurisprudenza :" Turin. "Legislation des Irrigations," par M. Mauny de Mornay. "Traité des Irrigation," par M. Nadault de Buffon,—tom. iii. Legislation.

"II. No one can establish canals or channels for the introduction of water into his property, either for the use of mills or other buildings, unless he possesses a legitimate title to the same, or has obtained a royal grant."

Doubts having arisen as to the proper interpretation of several parts of the patent of 1817, a new regulation was published on the 14th February 1828, embodying the conditions on which the Government right of property was in future to be exercised; and as this continues in operation at the present time, I give it here, in illustration of the system of disposing of the water in Piedmont.

"INSTRUCTIONS to the INTENDANTS of PROVINCES and the AGENTS of the ROYAL DOMAIN, in connection with GRANTS of WATER from RIVERS and TORRENTS.

"All the rivers and torrents of the State are *regali*, and belong in consequence to the royal domain.

"Hence, therefore, the sovereign permission is necessary before the waters can be used in any way whatever, either in agriculture or industry.

"Sundry statutes and patents formerly published have hitherto regulated the provisions for grants; but as it is desirable to establish one uniform rule of procedure in such cases, the Secretary of Finance, whose duty it is to obtain the royal sanction to proposed grants of water, has decided that in future the following orders shall be observed:—

"I. Parties desirous of obtaining grants of water from the regal rivers and torrents, whether for irrigation or the movement of machinery of any kind, ought to present to the intendant of the province where the head of the proposed derivation is situated, petitions addressed to

H. M., and authenticated by the signatures of the petitioners, or by those of a notary and advocate.

" II. To each petition the under-mentioned documents should be attached :—

" (1*st.*) A regular plan of the locality, on which shall be noted the works which it is proposed to construct in the bed of the river or torrent,* and the adjacent ground so far as it may be connected with these works.

" (2*d.*) Longitudinal and transverse sections of the river whence the supply of water is to be obtained, marking thereupon the depths in times of flood, and under ordinary circumstances ; also the heights of the works to be established in the bed of the stream, and of the head of the water-course.

" (3*d.*) A detailed report proving the utility of the proposed works, and that they cannot cause any injury either to other parties, or to the river, or torrent itself.

" These documents ought to be prepared by a hydraulic engineer.

" But in the event of no hydraulic engineer being near the spot, or of the works being of limited importance, it is permitted, but with special reserve, to employ a civil architect, or land-surveyor, in the preparation of the papers above referred to.

" The intendants of provinces will render all practicable assistance to parties interested, so as to enable them to comply with the orders of the superior authorities.

" III. The petition and the documents above specified should all be prepared on stamped paper (*in carta bollata*).

" IV. The intendant, on receiving the claim and its annexures, shall satisfy himself of their regularity, and

* Perhaps it may be as well to say, that in Northern Italy, streams having perennial volumes of water are distinguished as *Fiumi*, while those having intermittent supplies are termed *Torrenti*.

shall depute the official engineer of the province to visit the spot at a specified time, to investigate the practicability of the project, and the propriety, or otherwise, of carrying it into effect; as also to decide on whatever precautions or modifications regard to public or private interests may require.

" V. The visit ought to be preceded by a public notification of the claim within the limits of the district specially interested in it.

" If the claim and the works proposed are in any way connected with the interests of more than one district, the notification should be made contemporaneously throughout the whole.

" VI. The order of the intendant for the notifications should contain a brief summary of the nature and extent of the proposed works, and an invitation to all parties interested in them to be present at the time appointed for the visit, when they can explain their views either verbally or in writing.

" VII. The report of the official engineer ought in all cases to furnish full and clear details on the following points :—

" (1*st.*) On the quantity of water to be taken from the river, and the special use to which it is to be applied.

" (2*d.*) On the form and dimensions of the head (*imboccatura*) to be constructed; being careful to note that the provisions expressed in Art. 16 of the regulation of the 29th May 1817 are rigorously to be enforced.*

* I may give these here :—

" Art. 16. All proprietors, tenants, or employers of water-courses, are bound to maintain the head works in an effective and satisfactory condition. They are personally responsible for whatever damages may befall neighbouring properties, unless they can prove that these arose from causes over which they had no control.

" The aforesaid proprietors or employers are farther bound so to regulate the supplies of water, as that in time of flood they shall not exceed the capacities of

" (3*d*.) On the directions, heights, lengths, form, and mode of construction of the dams required to raise the water.

" (4*th*.) On the precautions to be observed by the grantee when the supply is obtained by means of temporary dams (*chiuse instabili*), in replacing the same after floods. Grantees being generally inexpert and careless in hydraulic operations, a matter so important as the preceding should not be left dependent on their wills, but definitive measures should be prescribed, whereby the injuries likely to be caused to the beds of rivers or torrents, by badly-constructed dams, may be guarded against.

" (5*th*.) On the capacity and slope of the canal for the passage of the water.

" (6*th*.) On the means and precautions to be adopted to insure the regular execution of the works—to restore (when such is possible) the water to the stream at a lower point, and to protect all parties from damage by overflow of the canal or otherwise.

" (7*th*.) And finally, the official engineer ought to detail any local peculiarities which may have influenced his opinion.

" With such information before it, the Permanent Congress of bridges and roads (to which the project will be referred) can better decide on the propriety of sanctioning its final execution.

" The various documents above referred to shall be attached to the royal patent authorising the grant, in order that both the administrative and judicial authorities may always have the means of ascertaining precisely the

their respective canals. Adequate escapes for the excess of water under such circumstances shall be constructed, under penalties for each offence varying from 10 to 100 *lire* (from about 8s. to £4), in addition to the cost of repairing the injuries caused.

terms of the said grant, and of restricting the grantee within the limits of the same.

"VIII. On the receipt of all the papers connected with the case, the intendant shall forward the same to the agency-general of finance, with his own opinion upon them.

"IX. So soon as the agency-general receives notice from the secretary of finance that the royal patent for the grant has been signed, it will communicate without delay with the intendant, who will transmit the information to the official engineer, to the syndic of the district, and to the petitioner, requiring the latter to procure the aforesaid patent from the secretariat of finance, and to pass it through the offices of the agency and the chamber of accounts, within the space of four months, under pain of forfeiture.

"X. The receiver-general shall be supplied with the necessary instructions to enter the patent in his list, and to arrange for the recovery of the annual water-rent."

The Civil Code of Charles Albert, published in 1837, confirms the provisions of the preceding enactments on the right of property in water. The articles connected therewith are the following,—those portions of them which do not concern the present subject being omitted:—

"Art. 420. The . . . . . rivers and torrents, ... and generally all those portions of the territory of the State which cannot become private property, are considered as dependencies of the royal domain.

"Art. 431. The provisions of articles 425, 429, and 430,* do not apply to property adjudged to the royal

* These articles guard the rights of the crown from any infringement, and prescribe certain formalities to be observed by all parties obtaining grants which in any way affect these. They are not connected with my subject, except remotely, and it does not appear necessary to translate them.

agency, or received by it, in payment either of taxes or any other dues. . . . . Nor, finally, to grants of water belonging to the royal domain, nor to any exchanges of these waters which may be made.

"The alienation or grant of such property as is specified in this article is subject to special rules. This alienation or grant ought always to be approved of by the chamber of accounts, the procurator-general having first been heard. Without this sanction, the alienation or grant becomes null and void, and the chamber is charged to guard against any prejudice either to the crown or to any third party."

The "special rules" adverted to in the latter part of the preceding article, in so far as grants of water are concerned, have already been given, and I have found none of any later date than 1828.

The extent to which private individuals can acquire a right of property in water is defined in the following articles of the civil code, Title IV. Chapter I. :—

"Art. 555. He who has a spring on his lands can use the same at his will, saving the right which the proprietor of the lower land may have acquired by title or prescription.

"Art. 556. The prescription in this case can be acquired only by an uninterrupted enjoyment during the space of thirty years, calculating from the moment when the proprietor of the lower land made and finished on the upper land visible works, designed, and which have actually served, to facilitate the descent to, and the passage of the water through, his own property.

"Art. 557. The proprietor of the spring cannot change its course when the water necessary to the inhabitants of a commune, village, or hamlet, is obtained from it; but if the inhabitants have neither acquired nor prescriptive

rights to the water, the proprietor may demand an indemnity, which is regulated by the tribunals, on the report of professional men (*a giudizio di periti*).

"Art. 558. Any one whose land borders on a stream flowing naturally, and without the aid of works executed by man, and which has not been included among the rivers, streams, and torrents, declared in Art. 420 to be the property of the royal domain, may make use of it during its passage for the irrigation of his property.

"Any one whose property is intersected by the same stream may make use of it within the limits of his own land, with the obligation, however, of restoring the water to its natural channel on its passing beyond the boundary line of his estate.

"Art. 559. In the event of any dispute arising between the proprietors to whom such waters could be useful, the tribunals, in deciding, ought to conciliate the interests of agriculture, with, at the same time, a due regard to the right of property. And in all cases the local and special rules which regulate the course and use of the waters ought to be observed.

"Art. 560. Every proprietor or possessor of water may make such use of the same for himself as may seem to him good, or he may dispose of it in favour of other parties, provided always that no title or prescription exists to the contrary; but after having used the water himself, he is not at liberty so to dispose of it as to cause it to be lost, to the injury of lands at lower levels, which might have benefited by it, without causing any backwater, or injuries of other kind to the superior employers. Whoever may desire to avail himself of the water referred to is bound to pay a fair price for it, whether the supply be derived from a spring existing in

the superior estate, or from a stream introduced by special grant."

From these extracts, it is to be observed that the same general principle regulates the Piedmontese and Lombard legislation, in so far as private rights to water are concerned. The springs which rise, either by hydrostatic pressure to the surface of the ground, or are found beneath it by artificial works, belong to the individual proprietors of the soil. These sources of supply bear the same relation to the natural water-courses of the country as the irrigating wells of India do to the streams and canals there. While every proprietor can dig his well where and how he chooses, he is prohibited from using the stream which flows past or intersects his land, without the special permission of the Government. I ought, however, to say, that both in Northern Italy and Northern India this is rather the theory than the actual practice in the case, for there are instances in both regions where, perhaps in remote places, in mountain valleys, or like localities, the running streams have been used for ages by the inhabitants without let or hindrance, or acknowledgment of superiority of any kind. The framers of the Albertine code, wisely respecting rights founded on immemorial usage, include all such cases under Arts. 558 and 559, which seem to be most judiciously adapted to the peculiar circumstances under which these exceptions to a general rule have arisen. The local customs which have grown with the growth of the system of irrigation, and have consequently the support of experience and familiarity, are prescribed to the tribunals as their chief guides in the case of disputes; the interest of agriculture and the right of property are to receive each its due consideration; and the benefits of the stream are to be distributed as fairly as possible among

its common employers. Should the government of India ever be led to legislate on irrigation in detail, I have no doubt that the same regard will be shown to rights which have grown up during centuries of use, and in dependence on the stability of which, various hydraulic and agricultural works have been executed by the proprietors of the lands adjoining the streams. I am indeed bound to say that, in some instances of this class which came under my own observation, wherein rights founded on usage of no great antiquity were interfered with, the amount of compensation granted was most liberal, and I am certain the same spirit will characterise all future dealings with the interests of irrigation.

Art. 560 involves a principle so important, that I may advert specially to it for a moment. There are strange tales told of water-feuds in Piedmont—of proprietors of springs, or grantees of canals, who, to injure neighbours with whom they had standing quarrels, have wasted utterly the water by which the properties of the latter might have been benefited. A curious anecdote in illustration of this point is related in M. de Buffon's work (vol. iii. p. 301), which I may give here. The relator is the Count de Cavour, the present minister of finance in the cabinet of Sardinia. "I have had under my own observation," M. de Cavour remarks, "an example of the abuses which Art. 560 of the new code is designed to prevent. In 1832, the Marquis of St G——, farmer of the canals of the Vercellese, having quarrelled with his neighbour, the Marquis Pal——, persisted, during eight consecutive years, in throwing into the river Po two *ruote* (about 24 cubic feet per second) of water, for which the Marquis Pal—— offered to pay him 12,000 francs (about £500) a-year. To satisfy a personal antipathy, M. de St G—— consented to sacrifice nearly 100,000 francs (about £4000),

causing, at the same time, a loss to the agriculture of his country of triple this amount at the least. The new code puts an end to a state of affairs so deplorable. It required, however, a decision of the senate of Turin, based on Art. 560 of the code, to compel the Marquis of St G—— to have his revenue increased by £500 a-year!

"This same Marquis of St G——, wishing to force the commune of T— to submit to an arrangement which it regarded as oppressive, refused to allow the surplus waters of his vast domains to flow into the lands of this district, although he was offered 6000 francs (about £250) a-year for them. He preferred throwing them, for two years, into the Po, to his own loss, and to the injury of his neighbours.

"Marquises of St G—— are scarce, it is true; but as they are not impossible, the law does well to deprive them of the means of injuring people less rich or less powerful than themselves."

I think few will dissent from M. de Cavour's conclusion; for if it is ever necessary that a man should not have full power to do what he likes with his own, or that the duties of property should be enforced equally with its rights, surely it is when the very sources of agricultural progress are concerned. I think, therefore, that the principle of requiring every proprietor of water, however procured, to place it at the disposal of his neighbours on equitable terms, after his own wants have been fully supplied, is one of great importance in the legislation of irrigation, and well worthy of adoption by us in those regions in the East where great canals are in progress. I may only farther remark, that the anecdote just related gives point to the objections I expressed in my personal narrative to the system of farming the royal canals of Piedmont to private individuals, who, with personal anti-

pathies to gratify, or personal interests to enforce, will inevitably find the means of doing both in the great powers with which they are invested.

Eastward of the Sesia, the right of property in the rivers and torrents, appertaining to the State, is exercised solely for general supervision and control. The whole of the waters of the streams flowing between the Sesia and the Ticino have been alienated from the State under ancient grants of ancient kings or dukes, and are possessed either by associations or individuals. The revenues are appropriated by these parties to their general or particular benefit; and the State claims only to have all internal regulations submitted to its inspection, and enforced only after having received its approval. On all the royal canals in the Vercellese and other provinces, the right of property is fully exercised, and the revenues become part of the income of the kingdom.

The holders of ancient grants in perpetuity have occasionally asserted an absolute right of property in the water thus granted to them; but the legal tribunals have invariably rejected such claims, on the ground that the grants were made for the general good of the country, as much as the special advantage of the grantees. The large canals Mora, Busca, and Biraga, derived from the Sesia, have been held by grantees since the close of the fifteenth century. On these works a very large portion of the irrigated land of the province of Novara is dependent, and the outlets are held under annual leases continually renewed. Farther to the southward, in the district of the Lumellina, water is less abundant, and therefore bears a considerably higher value. This latter fact led the grantees of the canal Mora to attempt, about the close of the last century, to discontinue the supplies which had been furnished for centuries to a number of proprietors

near the head of the canal, with the view of carrying the water thus obtained to the southward, and there renting it at higher rates. To this project very decided opposition was naturally enough offered by the parties whom it was thus proposed to ruin. It was held by them that the annual agreements were intended simply to regulate the manner of obtaining the supply and the amount of rent to be paid, but that the grantees of the canal had no right to deprive them of the water they had so long enjoyed; that the very terms of the original grant itself were opposed to such a course, since they specifically state that "the good of the country" was as much the motive of the grant as the advantage of its holders; that in this faith they and their ancestors had, at great cost, constructed aqueducts and many other works in brick and stone, which would become utterly useless; that they had broken up, cleared, and levelled the ground in such way, that it could not readily be adapted to dry cultivation; that they had invested a large amount of capital in these various operations, which would be thrown away; that the province, now rich and fertile, must become wretched without water; that, finally, their lands had all been taxed at the high rate fixed for irrigated estates, and that to sustain the claim of the grantees would entail an enormous loss to the royal treasury itself. The case was carried before the senate of Turin, which, by a decree under date the 13th April 1787, decided that the proprietors of the canal should continue to give to the employers of the water those volumes which they and their forefathers had so long enjoyed, pending the farther investigation of the case; and the employers were called upon to submit evidence in support of the reasons on which their opposition was founded. The suit was, however, pursued no farther; the grantees of the canal aban-

doned their design, and the employers continue to enjoy their ordinary supplies of water at the present day. The question was renewed by the grantees of the canal Biraga, between 1826 and 1830; and M. Giovanetti, from whose work I have derived the above details, states it was to himself that the employers of the canal were indebted for a series of definitive decrees by the senate of Turin, under dates the 22d December 1826, the 30th November 1827, and the 6th of March 1830, by which their claim to water, so long as they paid the established price for it, was finally confirmed, and all fears of their being deprived of the benefits of irrigation, by individual caprice or self-interest, were set at rest. In 1838, the grantees of the canal Mora returned to the charge, but were defeated by a decree of the senate of Casale, dated the 16th December of that year. The temporary effect of these decisions was to create an impression that no employer holding a term-lease of an outlet of irrigation could be deprived of it, so long as he paid the price for the water. Subsequent decrees of the courts, however, showed, that unless such outlets had been held for long periods*—had been established and maintained during these periods at considerable expense—had been accompanied by other agricultural works—and that no special agreement to the contrary existed between the proprietor of the canal and the lessee of the water—temporary leases were revocable at the will of the former. M. Giovanetti mentions, that he proposed to the commission on the civil code, to define and establish the principle involved in the decisions of the courts above referred to (technically termed *il diritto d'insistenza—le droit d'insistance*), and that it was accordingly

* The senate of Turin proposed a period of twelve years' uninterrupted enjoyment of water, under a temporary lease, as sufficient to give the lessee a right to the continuance of his supply, so long as he paid the fixed water-rent.

introduced into the first draft of the code. The senates of Nice, Savoy, and Turin, approved of the principle, only altering the terms of expression; but the Chamber of Accounts and the Senate of Genoa demanded its suppression as incompatible with the right of property. The commission on the code adopted the latter view; and the two articles defining the right were accordingly struck out. "This suppression, however," says M. Giovanetti, "can have no prejudicial influence on existing derivations of water, since for them the law has already been fixed; and for new ones, each lessee will take his own measures to secure the permanence of his lease for such term as suits his wants." Practically, that system which I have before described as obtaining in Lombardy holds good in Piedmont; and a landed proprietor may obtain a lease of a given quantity of water, either in perpetuity, or for a specified term, on paying the current price for the same.

I have not entered into the preceding details without an object. There are questions pending at this moment in India, between canals drawing their supplies from the same river, on which the principles recognised in the legislation of Piedmont have a direct bearing. The grounds upon which the decrees of the senates of Turin and Casale, in the cases of the employers of the canals Mora and Biraga, were founded, apply, *mutatis mutandis*, with equal force to the like cases of the canals of the Jumna in India. In coming, therefore, to a final decision regarding the proportion of the volume of the river to be allotted to each of the two canals fed by it, the relation in *time* between the leases of the employers of the water on each bank of the river is a point of the highest importance. If it should unhappily be necessary to reduce the supplies now granted to any of the cultivators, it is equitable that the most recent among them should give way

to the older, who have prescriptive rights of longer standing, invested capital of larger amount, and obligations to the Government of greater extent. This is no place to express at length my views on a question of merely local interest, and I make this brief allusion to it, because it has been present to my thoughts while preparing the foregoing details; and as I have found that the consideration of these has been useful to myself, I venture to think they may also be useful to others interested in the matter.

SECTION II.

ON THE LEGAL RIGHT OF PASSAGE FOR WATER IN PIEDMONT.

In the sketch of the progress of the legislation of irrigation given at the commencement of the present Part, I have traced in sufficient detail the introduction of the right of passage for water (*il diritto d'acquedotto*) into the legislative system of Piedmont, anterior to the code of Charles Albert. I may now, therefore, proceed at once to the examination of the right as detailed and defined in that code itself, or as explained and amplified in enactments posterior thereto.

The second chapter of Title IV. Book II. treats of servitudes on land established by the law; and Section V. of that chapter is devoted to the right of passage for communication and for water, as connected with agriculture, industry, or general improvement.

It is with the right as connected with the use of water only that I have to do; and I will now give translations of those articles of the code which specially affect it.

"SECTION V.—*Of the right of Passage for Water.*

"Art. 622. Every commune, university, or individual is bound to give a passage across their lands to water derived from rivers, springs, or any other sources, by parties having a legal right to the same, and wishing to employ it for irrigation, or for the use of hydraulic works. Farm-houses, with the courts, thrashing-floors, and gardens attached to them, are excepted from this rule.

"Art. 623. The canal required for the water shall be executed entirely at the expense of the party claiming the right of passage, and he shall have no title whatsoever to demand the said passage through canals previously in existence, and destined for the use of other waters. The proprietor of any farm, however, whereupon a canal carrying water of which he is the legal owner already exists, may prevent the opening of a new canal on the said farm, by offering to give a passage to the water of another through the pre-existing channel, always provided that this can be done without manifest injury to the party claiming the right of passage.

"Art. 624. It is also permitted to carry water across existing canals and water-courses, in such manner as may be most expedient and best adapted to the locality, and to the condition of the said canals and water-courses. It is necessary that the works which may be constructed for the above-mentioned object shall not stop, check, or accelerate, or in any other way change the course or the volume of the water flowing in the canals or water-courses.

"Art. 625. In carrying water across public or district roads, or across rivers or torrents, the special rules of the department of roads and waters shall be observed.

"Art. 626. Whoever desires to carry water across the lands of another, is bound to prove that the quantity of

water whereof he is the proprietor is sufficient for the purpose to which it is destined; that with reference to the circumstances of the neighbouring farms, the slope, and the other conditions of the channel, the course, and the free escape of the water, the line of passage demanded by him is the most convenient, and, at the same time, is that which will cause the least possible injury to the estates affected by it.

"Art. 627. The party desirous of carrying water across the land of another is bound to pay in advance, and before the construction of the canal is commenced, the estimated value of the ground to be occupied, without deduction of the land-tax, or any other burdens which may be inherent in the soil, together with one-fifth of the said value in excess, and also compensation for immediate damages, including those due to the division of the estate into two or more parts, or any other deterioration which may follow on the intersection of the land.

"In cases wherein the right of passage is claimed for any period less than nine years, the amount to be paid by the claimant shall be limited to one-half the value of the land occupied by the works, with the fifth in excess, and compensation for damages as above detailed. The claimant shall further come under obligation to restore everything to its original state on expiry of the term agreed upon. If the party who has obtained a temporary right of passage should desire to change it into a permanent one, the payment of the half value of the land, and the other terms annexed to the former, shall not be taken into account in settling the conditions of the latter.

"Art. 628. Any one availing himself of the offer made in terms of Art. 623, to allow his supply of water to flow through the canal of another, is bound to pay, in proportion to the volume of water introduced by him, his share

of the value of the land occupied by the works, of the excess and compensations as above fixed, and farther, to defray in the same proportion the charges for repairs, maintenance, and every other expense which the introduction of the said water may have rendered necessary.

"Art. 629. In the event of the party who has obtained the right of passage for a certain quantity of water desiring to increase the same, he shall be bound to show first that his canal has sufficient capacity to contain the greater volume, and that no injury can result to the estate subject to the servitude. When the introduction of the larger volume of water requires the construction of new works, the nature and extent of these must be determined; and the value of the soil to be occupied, according to Art. 627, must be paid prior to the commencement of the said works.

"Art. 630. The terms established in the foregoing articles for the passage of water apply equally to the case of the proprietor of a marshy estate, who desires to improve the same either by the process of *warping* (*colmata*), or by the excavation of one or more canals of drainage.

"Should opposition be made to the drainage of the estate by parties having rights to the waters on, or flowing in any way from the same, the tribunals, in deciding, ought to have due regard to sanitary and agricultural interests, and also to the use made of the water by the objecting parties.

"Art. 631. The grants for the use of water appertaining to the royal domain are always made on condition that they involve no prejudice to anterior and legitimately-acquired rights to the use of the same water.

"Art. 632. Parties having the right to extract and derive water from rivers, streams, torrents, canals, lakes, or reservoirs, are bound to avoid injuring those situated above

or below them respectively, by the stagnation, or by the return, or by the change of course of the said water. Whoever, by neglect, may cause any damage in these ways, shall be bound to repair the same, and farther, to suffer such punishment as may be established by the regulations of the rural police.

"Art. 633. In cases where the waters flowing for the benefit of individuals prevent the adjoining proprietors from passing freely to their estates, or check the circulation of water in the irrigation or drainage of these, the parties benefiting by the water are bound to construct and maintain in good order the bridges necessary for intercommunication, in a sure and convenient manner. They are farther bound to construct and maintain such culverts, aqueducts, and other like works, as are required for the free progress of irrigation or drainage, saving an agreement or legitimate title to the contrary."

The preceding eleven articles define very clearly and distinctly the right of passage as enjoyed in the irrigated districts of Piedmont; but before making any remarks upon them, there are some other portions of the code which are intimately connected with the present question, and which it will be most in order to give now.

The right of passage for water is regarded in Piedmont as a simple servitude, involving no right of property in the land occupied, and giving to the party exercising it no other claim than to mere transit for the water belonging to him, under such conditions as may make it effective to the end contemplated. It is so defined in the following articles:—

"Art. 640. The servitude of taking water by means of a canal, or other visible and permanent work, for use in agriculture or industry, or for any other object, is included among the number of continued and apparent servitudes.

"Art. 654. The establishment of a servitude is held to involve the grant of everything necessary to its use.

"Thus the servitude of obtaining water from the spring of another involves necessarily the right of passage.

"Art. 663. The right of passage for water does not give to the party exercising it any right of property, either in the land at the sides, or forming the bed of the spring or water-course; and the land-tax, with all other burdens attached to the soil, shall be borne by the proprietor of the aforesaid land."

In examining the whole of the preceding articles, the first point to which attention may be directed is, that the right of passage in Piedmont has been made applicable, not only to water directly employed in agriculture and industry, but also to the waters of marsh lands or other localities, where their existence would be injurious to the public health or interest. It is held that the drainage, or the improvement by the process of *warping*, of such localities, has an influence on the general good of the community scarcely inferior to that of irrigation itself; and that he who is prepared to invest his capital in changing miasmatous swamps into fertile fields, is entitled to aid at least equal to that afforded by the laws to the proprietor of water employed in increasing directly the products of agriculture and industry. The interests of those who may have obtained prescriptive or titular rights to the waters and marshes, are not overlooked; and the tribunals with which the decision of disputed cases rests, are enjoined to conciliate such interests in so far as may be compatible with the salubrity of the atmosphere and the good of agriculture.

The right of passage is also applicable to the *colature* or surplus waters, which remain after the first irrigation of land has been effected, and the interests of tenants of

land under temporary leases are secured by Art. 627 in a manner peculiar to Piedmont. This latter arrangement, whereby tenants possessed of capital, and willing to invest it in the improvement of their farms, may obtain the right of passage for any period less than nine years—which by the custom of the country is the usual limit of leases—is one of the highest practical value, and exercises a powerful effect on the general progress of agricultural improvement. It may therefore be said that in Piedmont the legal right of passage for water has received its most comprehensive application; that the free circulation of those waters, on the use or due control of which the prosperity of the most productive portions of the kingdom is entirely dependent, has been secured by the most liberal arrangements consistent with a due regard to the rights of property. Public opinion cordially sustains this liberal policy; the genius and traditions of the people, the agricultural customs which have taken root among them, the experience of the past, and a clear apprehension of their true interests, have all co-operated in securing a general approval of the provisions of the civil code in the matter of the right of passage for water. "It is clear," says M. Giovannetti, at the close of his elaborate examination of the present question, "and it may be frankly stated, that in Northern Italy the right of passage has received the most solemn sanction, popular, political, and legal."

Having thus adverted to the comprehensive application of the right, I may next notice the guarantees to property by which its exercise is accompanied. Among these the first is, the protection afforded to all farm-buildings, and the land specially connected with them. The propriety of this exception has been questioned, on the grounds that the sole line which a water-course could take might be through such lands; that the proprietor of a farm-house,

garden or court attached to it, was sufficiently protected by the obligation imposed on the claimant of the right of passage, to prove that the line selected by him was the most convenient, and the least injurious to the estates affected by it; and that the tribunals could, by ordering the canal to be covered, or by other appropriate measures, prevent any real inconvenience to the occupants of the farms. The Legislative Commission, however, was not satisfied with these reasons, and the code accordingly maintains the exceptions adverted to. It is possible, but, in a region having the physical features of the valley of the Po, certainly not probable, that inconvenience might result from the determination of the commission.

The vexed question of the right of passage through previously existing channels has been very judiciously disposed of by the Sardinian legislation. To have continued this right to the possessor of water in the absolute manner established by the ancient legislation of Piedmont, would, as experience had already shown, have led to constant and harassing disputes. The edict of Charles Emanuel III., published in 1770, and on which the right adverted to was founded, had been followed by repeated law-suits; and though the judicial tribunals had necessarily decided all cases in accordance with its provisions, the senate of Turin had especially recorded its opinion that the law was one of great severity. It is also recorded that there was scarcely ever a single case in which the results of the union in the same canal, and the subsequent division of the water belonging to two different proprietors, were satisfactory to both. Hence, in the new code, the right of the proprietor of the water to demand a passage through pre-existing canals is specially abrogated by the first paragraph of Art. 623. But as instances might arise in which it would be ruinous to an estate to be subdivided

farther by canals, its proprietor has the power of preventing this under the second paragraph of the same article, by offering the use of the channels already in existence, always provided these can be employed without notable injury to the other parties. It is not often that this power is acted upon, for there is a general impression against mixing waters; but when special cases arise, to which, by mutual consent, it is fairly and conveniently applicable, it is well to be able to employ it.

To prevent the claim to the right of passage being made under fictitious circumstances, the claimant is bound to prove, by reference to professional opinion, that the quantity of water he has to dispose of is sufficient for the object contemplated, whether in irrigation or for machinery, and that all the conditions of his channel are the best practicable. There is much more minute care taken in the existing legislation of Piedmont, to secure at once the efficiency of the works and the minimum of injury to the land on which they are established, than in that of Lombardy. Experience had shown in the former country, that parties frequently excavated a small well or spring on land belonging to them; and though the quantity of water derived from it was very trifling, they claimed the right of passage through irrigated fields, or in the vicinity of previously existing canals, with the view of drawing from these sources an additional supply at the expense of their neighbours. It was to put an end to such proceedings that Art. 626 was framed by the commission on the code as it now stands, and it contains all the guarantees to property which could well be given in the cases referred to.

I may next remark, that the details of compensation for land occupied as fixed by Art. 627 seem very just and clear. The full value of the ground, estimated with-

out deduction on account of public or other burdens attached to the soil, with one-fifth of this value in excess, form the total direct compenstion. Incidental damages, of whatever nature they may be, are estimated separately, and separately paid for. It will have been observed, that almost every law on the right of passage to which I have had occasion to refer, has granted to the proprietor of the soil compensation in excess of its estimated value. The proportion of this excess varies in the ancient legislation from as much as double to as little as one-eighth of the value; but an excess is constant. The motive of this provision has been differently explained; some considering it to be a desire to reconcile landed proprietors to the system of forced exchanges; while others, with perhaps greater plausibility, regard the excess as a compensation for the Government land-tax, which the proprietor continues to pay, though deprived of the use of the ground. Whatever its original source may have been, its existence has received a new and permanent sanction from the Albertine code, which has fixed its amount at one-fifth of the gross value of the soil. In Lombardy, it may be remembered, the proportion is rather larger, being one-fourth.

Article 629 involves an important principle, worthy of notice. The proprietor of a spring, or an outlet from a canal, having obtained a servitude of passage for the volume of water derived from it, has a deep interest in increasing this volume, and in carrying the increased quantity through the existing channel. He thus adds to his means of irrigation, without adding at all to the expenses required for the passage of the water. So long as this is done without in the slightest degree affecting the interests of the estate subject to the servitude, there can be no possible objection to it. But it is well known

to all concerned with such points, that to increase the volume of water carried by a channel whose dimensions have been fixed for a smaller quantity, may entail seriously mischievous results, as, in fact, the conditions of the problem are all changed by the change of this most essential element. Hence the code forbids any augmentation to the discharge of a channel without a previous investigation by qualified parties, who must ascertain that its capacity is sufficient, and that no injury will be caused to others. In practice this article has a large range; it affects the whole of the works of a canal, as none of these can be changed—no aqueduct, for example, can be substituted for a culvert; no passage *under* for one *over* the water-course of another party; and so on,—until it has been established that the proposed change is an innocent one, or, if it be not, until due compensation for the injury it will cause has been settled and paid. And if the quantity to be added to the old supply is so considerable as to require an enlargement of the channel and additions to the works, the whole of the precautions and provisions established by Article 627 have to be observed, as though a new passage were being negotiated for. The interests of both parties concerned are thus equitably adjusted.

The other provisions of the code do not seem to call for any special remark. The reservation of anterior rights in all new grants of water belonging to the royal domain, the obligation on all proprietors of water to maintain their channels in perfect repair, the rules for the distribution of expenses among joint proprietors of the same water-course, the maintenance of the means of intercommunication which the exercise of the right of passage may interfere with—are all just, clear, and practical details, of which a simple record is sufficient, and on which it would be tedious to dwell at length.

The foregoing provisions of the code on the right of passage apply exclusively to the construction of canals belonging to private parties. There are works of the same order, however, which, as affecting larger interests, may be declared works of public utility, and as such be brought under a different series of provisions, to which, before concluding the present section, I may briefly advert.

The following articles of the civil code regulate in general terms the occupation of property for purposes of public utility :—

"Art. 441. No one can be compelled to cede his property, or to allow another to make use of it, unless for objects of public utility, and on receipt of a just compensation, payable in advance.

"The works of public utility, and the property to be occupied by the same, are determined under provisions emanating from the sovereign.

"The rules to be followed in the aforesaid cases shall be fixed by special laws and regulations.

"Art. 442. When the parties cannot agree before the administrative authority on the amount of the indemnity to be paid, the disputes shall be decided by the legal tribunals."

On the 6th of April 1839, a special law was published, regulating at great length all matters connected with the class of works above referred to. As it consists of seventy articles, and as by far the larger number of them have reference to matters of detail only locally applicable, I need not give the act in full.

The first and second articles are to the following effect :—

"Art. 1. Works of public utility are those executed on account of the royal domain, of the state administrations,

of provinces, and of communes. Such works, and the property to be taken possession of in execution of the same, shall be determined under Article 441 of the civil code, by letters-patent issued under the advice of the council of state.

"Art. 2. Works executed by associations or single individuals may also be declared of public utility by appropriate letters-patent, whenever their importance, or their influence on the development of the general prosperity, is such as to warrant this character being attributed to them."

The declaration that any particular works are of public utility, relieves them from the conditions prescribed in Articles 626 and 627 of the civil code, and brings them under those of Articles 441 and 442. Hence the land occupied by canals of this class becomes, on payment of an amount of compensation—to be agreed upon between the parties, or decided by the legal tribunals—the absolute property of the associations or individuals to whom the canals belong. The passage of the water is not effected, as in purely private works, by a right of simple servitude, but under a forced sale of the ground occupied by the channel. Articles 11 to 47 of the patent of the 6th April 1839 are devoted to defining clearly the terms of this sale when it can be effected by amicable arrangement under the sanction of the intendants of the provinces. The general object is to grant a just compensation for the ground occupied, or the injuries unavoidably caused by the works, but nothing more; no excess as in private cases, but the simple value of the soil, estimated on the basis of the actual returns for ten years preceding the period of forced sale, or on other similar data. Articles 48 to 70 prescribe the rules to be followed by the tribunals in the event of questions of compensation being

referred to them, and authorise in certain emergent cases, as in breaches of river or canal embankments, summary possession being taken of land necessary for the works. The tribunals, if dissatisfied with the estimates of value made under orders of the administrative authorities, can direct new ones to be framed by engineers selected by the disputants, or, if that is impracticable, by themselves. In cases of dispossession (*espropriazione*) under the present law, all burdens, public or otherwise, attached to the land, become transferred to the new proprietors.

To remove all doubts concerning its principles, and the manner of applying the law of the 6th of April, the Secretary of State for the Interior published, on the 12th of June 1839, a series of instructions to the intendants of provinces, which he desires may be regarded as a commentary on the law referred to. The first of the series, consisting of forty articles, embraces all details connected with the declaration of public utility; the second, in one hundred and sixteen articles, prescribes the various forms to be observed in adjusting the amount of compensation in communication with the administrative authorities; the third, in twenty-four articles, defines the powers of the legislative tribunals in the same matter; and the fourth, in thirty-three articles, refers to certain exceptional cases and special provisions. It is only to those details which particularly affect canals of irrigation that it is necessary for me to advert here, and I will do so as rapidly as I can.

"The law of the 6th April," the secretary of state remarks, "declares in its first article that works of public utility are those executed on account of the domain, the administrations, the provinces, and the communes. This definition, however, is not to be understood in a sense so extensive and absolute as to include every work of every

kind which is undertaken by these bodies. Thus, for example, should a commune construct a house, a mill, or a work of any kind, designed for the improvement of its own lands, or the increase of its own revenues, it is to be regarded in such cases merely as a proprietor, since there are no larger interests involved than those of any private individual undertaking works of the same class. The object is too limited to involve the idea of public utility as understood by the legislature. But whenever the limit of simply private interest, whether in the case of corporate or individual proprietors, is passed, and the work is designed for public use, the declaration of public utility may be claimed without reference to the special nature of the work.

"Therefore, canals and water-courses, provided they have a material influence on the public advantage, become included among those works on behalf of which the declaration of public utility may be made.

"In fact, although the civil code has established certain special rules for canals and water-courses, with the view of facilitating their construction by private parties, it does not thence follow, that, when they present all the characteristics of other works of public utility, the benefits secured by the laws to such works should be denied to them.

"It is accordingly to be concluded that, when projected canals possess the characteristics of works of public utility, they shall be so declared, with the view of applying to them the provisions of the law on dispossession.

"But, on the other hand, when the canals and water-courses are projected with a view to private interests only, Articles 626 and 627 of the civil code shall be applicable to them."

In reviewing the foregoing details, it appears that in Piedmont, canals of irrigation, in so far as the right of

passage is concerned, arrange themselves into two great classes: 1st, Canals of such magnitude and importance as to warrant the administrative authorities of the State in declaring them works of public utility; and 2d, Canals involving interests so restricted as to be regarded as purely of a private character. To both the right of passage is guaranteed, and the free circulation of water of irrigation is thus secured; but, in the first case, this right is one of absolute proprietorship of the land occupied by the works on payment of a fair compensation; in the other, it is simply a right of servitude, carrying with it no proprietary rights whatever; subject to the provisions of the code affecting servitudes generally; and acquired only on payment of the full value of the land estimated without deduction of burdens, with one-fifth in excess, and on compliance with the various other regulations established by the code.

Such is a summary, in general terms, of the state of the present question in Sardinia; and I am sure that the various details which have now been given deserve the serious consideration of all interested in the progress of irrigation in India. I have already had occasion to state, that the right of passage is recognised there in a rude and elementary form, unaccompanied by any definitions of its terms, or by any guarantees whatever to the private rights of parties affected by it. It will be impossible, as I am satisfied it would be most unjust, to allow matters to remain permanently in this undigested state, while our irrigation system is expanding so rapidly. There are points of similarity in the fiscal administrations of Northern Italy and Northern India, which would admit of the regulations connected with the right of passage in the former region, and especially in Piedmont, being transferred to the latter, with such modification as local pecu-

liarities might require. The great canals of supply in India, and the chief distribution channels which affect interests of considerable extent, might take their places among works declared of public utility by the local government, and have the right of passage on terms analogous to those prescribed for such works in Piedmont; while the water-courses of village communities or private proprietors might have the same right, on terms more favourable to the owners of the land occupied. At present, however, I do not wish to enter into details on these points; nor perhaps is this the proper place or time to do so. I earnestly commend the principles which are to be found in the Piedmontese legislation on the present subject, to the consideration of those interested in the future progress of the canals of Northern India and the Punjaub. I believe they may be adapted to the local institutions of these countries with most beneficial effect, but they are new to us; and I feel that, before any special method of applying them could be devised with good effect, they should be subjected to examination and discussion by parties on the spot, and familiar with the habits, feelings, and wants of the populations among whom it is sought to introduce them. I wish to see our present arrangements affecting the right of passage placed on a broad and sure foundation, satisfactory at once to the Government and to the agricultural community. But to effect this, many minds must combine their efforts—much local information be collected and discussed; and it is in India, not in England, that the improvements contemplated can best be matured. I have sought to furnish the rough materials for these; and hereafter I may perhaps be permitted to participate in the task of reducing them to forms suited to the nature of the works, and the necessities of the countries for which they are designed.

SECTION III.

ON THE MEASUREMENT AND DISTRIBUTION OF WATER FOR IRRIGATION.

Before giving the articles of the civil code which now regulate the matters comprised in the present section, I may briefly describe the modes in which water is ordinarily issued for irrigation throughout Piedmont.

There are three methods of distribution in common use. 1st. The distribution according to the *Use* made of the water, for which an unregulated outlet (locally termed *bocca libera*) is employed. The irrigation of any given area of land, without reference to the precise quantity of water such irrigation may consume, comes under the present head. For example, rice-lands are invariably irrigated from unregulated outlets ; and the only condition attached to this mode of issuing water is, that the object contemplated, be it agricultural or industrial, should be fully and efficiently accomplished. The free outlet of Piedmont is precisely that which is in use on all the canals of India, where no specific contracts for measured quantities of water have yet been formed, and where the area irrigated is the only point taken into consideration. The free outlet is generally of the simplest form, being merely an opening in the bank of the canal, unprovided with any measuring apparatus whatever. The volume it discharges is of course very indefinite ; and as any change in the circumstances of the canal of supply at once affects it, disputes are of frequent occurrence. The tribunals show much jealousy of alterations in the main lines of canals on which such outlets exist, for these derange at

once the ancient relations between the proprietors of the canals and the consumers of the water, inevitably almost inflicting injury on the one class or the other.

2d. The second method of distribution has reference to the *Time* for which the water is granted; and for this the unregulated or regulated outlets (the latter are termed *bocche tassate*) are employed indiscriminately.

3d. The last method has reference to the *Quantity* of water distributed, and for this only the regulated outlet can be employed. The forms of this kind of outlet have been already described in Part III., so that it is needless to advert to them now. On the three conditions specified, viz., the *Use*, the *Time*, and the *Quantity*, the distribution methods of Piedmont are based; and the framers of the code kept all in view in preparing the articles to which I have now to direct attention.

These articles are as follow :—

"Art. 641. In future, when an agreement shall be entered into for a constant and determinate quantity of running water, and the agreeing parties shall settle between themselves the form of the outlet or edifice of derivation, then that specific form only shall be observed. The parties concerned shall not be permitted to impugn its correctness on the ground either of excess or defect of supply, unless such difference in either way shall exceed one-eighth of the quantity agreed upon; and the action shall be instituted before the expiry of three years from the time when the work was first brought into use; always excepting the case in which the increase or deficiency of water may arise from changes in the supplying canal itself, or in the volume of the water flowing in it.

"If, in the absence of any agreement for a specific form, the outlet in actual use shall have been peaceably possessed and employed for the space of ten years, no com-

plaints regarding either excess or defect of water shall be entertained, excepting in the case of variations in the supplying canal, or in the course of the water flowing therein as above specified.

"In default of any agreement regarding the form of the outlet, or of possession, the form shall be determined by the tribunals, on the judgment of professional men (*periti*) nominated by consent between the parties, or, if they cannot agree, by the tribunals themselves.

"Art. 642. When grants of water, made for a specific service or object, do not express in terms the quantity granted, they shall be held to accord that volume which is necessary for the fulfilment of the said service or use. It shall be lawful for the parties interested therein to fix, at any time, the form of the outlet, and so to limit it as that the grantee shall receive the volume sufficient for the service agreed upon, but nothing more.

"When, however, the parties shall have agreed to give a definite form to the orifice of discharge or the outlet, or, in default of an agreement, there shall have been a peaceable possession of such a form for the period above defined, objections to the same shall be admitted only in the cases and within the periods established in the former article, (Art. 641).

"Art. 643. In new grants of water, wherein a constant quantity of running water shall be agreed upon and specified, the said quantity shall be expressed in all public acts in terms of the 'module of water' (*in relazione al modulo d'acqua*).

"The *module* of water is that quantity which, under simple pressure, and with a free fall, passes through a quadrilateral rectangular opening, so placed as that two of its sides shall be vertical, with a breadth of 2 decimetres, a height of 2 decimetres, and opened in a thin

plate, against which the water rests, and is maintained, with its surface perfectly free, at a height of 4 decimetres above the lower edge of the opening."

Such are the various conditions by which the civil code regulates agreements for water, based either on the forms of the outlets, or the use to which the water is destined. I have repeated the definition of the legal *module*, with the view of showing at once all the information on the subject to be found in the code. I would draw attention briefly to some of the peculiarities in this legislation. The first point to be noted is, that an agreement between the parties interested, as to the form of outlet to be employed, takes precedence of every other arrangement. The form may be an indifferent one; it may or may not have the guarantees for correctness which hydraulic science has pointed out; but if the parties are themselves satisfied with it, the law does not interfere between them, farther than by interposing certain obstacles to needless litigation. It is taken for granted that, if the proprietor of the canal and the employer of the water deliberately arrange, with the best advice they can procure, to make use of a certain form, and have the same constructed under their own immediate superintendence, or under that of parties in whom they have confidence, the result ought not to be lightly disturbed.

Some distinguished authorities* on the legislation of irrigation are disposed to think that, under such circumstances, the only grounds of objection which ought to be entertained are changes in the supplying canal, or in the volume or course of its waters; that it is better to maintain the terms of a deliberately formed agreement, even if they should not be perfect in their operation, than to

* Giovanetti in his *Treatise on Waters*, and Biangini in the *Annals of Jurisprudence, Fasciculus I.*, pp. 80-104.

admit uncertainties and disputes, which are always mischievous in their influence on agricultural operations. The framers of the code, however, were not disposed to adopt in all cases this extreme view, and they have followed a middle course, which experience has shown, I believe, to be judicious. It is clearly admitted that, in the present state of the science of hydraulics, it is not possible to construct an outlet which will discharge, at all times, and under all circumstances, the precise quantity of water which parties may agree to furnish and to receive respectively. Hence, to allow a margin for the influence of such admitted imperfections, the code has fixed a certain limit; and so long as they do not exceed this, either in excess or defect, the agreement cannot be impugned. This limit of one-eighth of the stipulated volume is held in Piedmont to be sufficient to include the variations likely to occur in forms of outlet, constructed with the best information now available. But there are still other limitations. Let the differences between the real discharges of the outlets and the quantities of water agreed upon between the parties be what they may, the use of such outlets for three years, without complaint on either side, bars all subsequent objections. It is held that, if the proprietor of the canal has allowed the employer of the water to use for three years the form of outlet agreed upon between them, without making any objections whatever, he has given sufficient proof that it fulfils his object, and protects fully his interest. A like inference is warranted by the silence of the consumer. Three years is an abundant time for both parties to become familiar with the operation of outlets established by mutual consent; and if no complaints arise on either side, the legislature is quite safe in removing the agreement beyond the reach of discussion afterwards, except, of course, in the case of

novel and unforeseen circumstances, connected with the canal of supply, arising to derange all previous calculations. A principle similar to the foregoing regulates cases in which no specific form has been agreed upon, but where an existing outlet has been tacitly used for ten years. I do not see clearly why, in this case, the time should be more than tripled, unless it be that mutual consent and deliberate consideration are less clearly implied than where specific agreements have been entered into. It is to be presumed that no proprietor of a canal would allow an outlet to be constructed arbitrarily on its banks, or that, if by some inconceivable possibility such an outlet had without his knowledge been established, he would fail to protest at once against it. Ten years seem needlessly long in such cases; but perhaps there are circumstances, not patent to a stranger, which justify the adoption of such a period.

When the service to be done by the water is the basis of the agreement, Article 642 prevents any doubt arising as to its terms. The quantity of water required to effect the object, be it the irrigation of 100 acres of rice, the driving of one or more water-wheels, or any other like end, is determined by professional men nominated by the parties, or by the tribunals if the case is carried before them; and it is open to the parties, when they think fit, to replace indefinite arrangements of this kind by the introduction of regulated outlets under the conditions prescribed for these.

Arts. 641 and 642 are connected with the relations of irrigation in existence prior to the publication of the Albertine code. The terms of agreements subsequent to that act, fall under the operation of Article 643, in so far as the expression of quantity is concerned. It has been, in fact, illegal since 1837 to use any other measure than the *modulo* of the code; and on all the Government canals, at

any rate, it is adopted. I have already, however, in Sect. I., Chap. I., Part III., entered into sufficient details on this point, and I need not occupy time and space in reverting to it here.

The methods of measurement and distribution by *Quantity* and special *Use* have now been adverted to. There remains the third method, by *Time*, to be noticed; and for this I have already mentioned that regulated or unregulated outlets are made use of indifferently. The distribution by time arranges itself in several subdivisions. These are—1st, Outlets for summer waters. 2d, Outlets for winter waters. 3d, Outlets for irrigation during the day. 4th, Outlets for irrigation during the night. The 3d and 4th varieties are in use particularly for meadows and gardens. 5th, Outlets for irrigation by horary rotation. All of these various outlets may be held under perpetual grants, under leases in perpetuity, or for limited terms; in fact, under any of the conditions referred to in the First Section of the present Part. They may farther, under these conditions, have rights to constant or intermittent supplies of water. The manner in which the Sardinian code deals with these various forms of irrigation by time, is shown in the following articles:—

"Art. 644. The right to a constant supply of water exists at every instant.

"Art. 645. The right to summer water (*acqua estiva*) exists from the equinox of spring to that of autumn; to winter water (*acqua jemale*) from the equinox of autumn to that of spring; and for water distributed at intervals of hours, days, weeks, months, or otherwise, for the time agreed upon or possessed.

"The distribution of water by days and nights is regulated by the natural day and night.

"The use of water on holidays is restricted to such

holidays as were in existence at the time when the agreement was originally made, or actual possession of the water obtained.

"Art. 646. In distributions of water made by horary rotation, the time necessary for the water to flow to the outlet of an employer thereof shall be included in his period of rotation; and the water which passes down the common channel at the changes of the rotation (locally termed the *coda dell' acqua*) belongs to the employer with whom the rotation terminates.

"Art. 647. The water which rises or leaks into the bed of the canal subject to the distribution by rotation adverted to in the preceding article, cannot be stopped or appropriated by an employer, except at his own proper period of the rotation.

A few explanatory remarks on the foregoing articles may not be misplaced. The definitions contained in Art. 644 prevent any doubts arising as to the precise meanings to be attached to common expressions used in regard to irrigation by time. It was not without a necessity for it that a clear definition of the meaning to be attached to the word *day*, when used in agreements for irrigation, was given by the code. It became matter of dispute before the judicial tribunals, as to whether the civil day, consisting of 24 hours, or the natural day, beginning with the rising and ending with the setting of the sun, was to be understood. The code decides that distributions, in terms of days and nights, imply the use of the latter, or the natural periods.

The agreements for irrigation on fête days are of very ancient origin, and invariably have reference to the use of the waters of streams employed ordinarily in driving the corn-mills of a town or community. As such works were stopped on holidays, the ancient statutes permitted the

water to be used at such times for irrigation. But fêtes are, as is known, very movable in their nature; they are created, suppressed, or changed, at the will of the church; and hence agreements into which they entered were constantly being affected, leading to numerous actions at law, and great doubts and difficulties. Hence the establishment by the Sardinian code of the principle involved in the final paragraph of Article 644, by which the fête days in existence at the time the agreement was entered into, or possession of the water obtained, are to be understood in interpreting the terms of such agreement or prescriptive right.

The conditions prescribed for the distribution of water by horary rotation appear very just and necessary. Until the point was settled by the code, it was occasionally in dispute, whether the loss of time due to the passage of the water from the canal of supply to the outlets of the different employers, should be borne by the proprietor of the canal, or by the consumers. It is established as a general rule that, when the water passes below the outlet of the common channel, any loss of time that may arise shall affect the employers only, being borne by each in proportion to his distance from the head, or from the outlet of the party which precedes him in the order of the rotation.

It is surprising to what an amount of learned legal disquisition that small volume of water, quaintly termed *the tail*, has given rise. The disposal of it has been a sort of trial-problem to all the great authorities on the legislation of irrigation; each has in turn broken a spear on its behalf with the others; and it has been to them something like the search for the philosopher's stone to the alchemist, or perpetual motion to the mechanician. Where doctors so learned have failed to convince each

other, it is not to be wondered at that an unlearned inquirer should feel somewhat bewildered; and I will only therefore say, that though different reasons are assigned for it by different parties, the conclusion embodied in the Sardinian code, that the employer with whom the rotation terminates has the best right to the *tail*, seems to be that which commands general approbation.

I have before mentioned, that, from peculiarity of physical structure, the soil of the irrigated region of Northern Italy is rich in subterranean springs, and that considerable supplies of water are occasionally afforded by these to the ordinary channels of irrigation. It has repeatedly become matter of legal inquiry to determine the parties to whom, in water-courses subject to the rule of horary rotation, these supplies properly belonged. It is also inevitable, in such cases, that certain small quantities of water should escape through the sluices attached to each outlet, and should pass on through the channel. The united volumes from subsoil springs and leakage-waters are sufficiently important to merit the special consideration of the legislature; and the decision, that no employer has the right to interfere with these out of his regular tour of rotation, sanctioned by Article 647, seems equitable and right. The period of rotation limits rigidly and distinctly each employer's right to the enjoyment of the volume of water in the common channel. While it lasts, he has the power of using every drop he can obtain from whatever source it may be procured; but the moment it ceases, his right becomes extinct. Hence, therefore, the surplus waters remaining, after the rights of all the employers have thus been duly satisfied, belong to none of them, but to the original proprietor of the water, or to that party to whom, by special agreement, the final excess of supply may have been allotted.

It is not uncommon, in the irrigated districts of Piedmont and Lombardy, for parties to make mutual interchanges of their periods of rotation. Special cases arise, in which water is wanted at special times, by individuals not possessed of the right to irrigate at such times. They therefore effect an exchange of period with other parties, to whom an arrangement of the kind may be convenient; and though the law is doubtful on the point—some decisions being in favour of, and others against, this proceeding—there does not appear to be any valid objection to its use, if it be guarded by the provision, that the other employers of the water-course shall sustain no serious damage by the manner in which it is carried into effect. An analogous custom is common in India: the positions of outlets on water-courses, held in common, are often changed; and so long as other parties do not suffer by this, the interests of agriculture are certainly promoted by its being freely made use of.

All the methods of distribution to which reference has been made, are subject to a contingency to which I have now to advert. The canals of irrigation, public and private, depend for their supplies on rivers liable to variations of volume, consequent on the natural influence of the seasons. These supplies are farther affected by accidents to the works of derivation, by the efficiency of the embankments for retaining the water in the canals, of the repairs and clearances of the beds, and so on. From the influences of these various causes, it may, and in fact constantly does happen, that the supply of a canal is inadequate to the demands upon it; and the obligations which arise out of such a contingency require to be provided for.

The obligations of the proprietor of a canal to the employers of the water supplied by it, and the provisions,

in case of deficiency, are thus established by the Sardinian code :—

"Art. 664. In default of special agreements, the proprietor or other granter of water from a spring or canal is under obligation to those who hold grants of him, to execute all the ordinary and extraordinary works required to procure the supply; to conduct and to preserve the water up to the points at which the employers take possession thereof; to maintain the buildings in an efficient state; to repair the bed and banks of the spring or canal; to effect the usual clearances; and to exercise due diligence, watchfulness, and care to insure the derivation of the water, and its regular supply being respectively made and given at the appropriate times, under pain of having to pay compensation for all injuries inflicted on the employers by his neglect of duty.

"Art. 665. If, however, the granter of the water can prove that the deficiency of the supply arose from natural causes, or from the acts of others, for which he could not be held responsible either directly or indirectly, he shall not, in such cases, be bound to pay compensation for the injuries sustained by the employers, but only to submit to a proportional diminution of the amount of water-rent, or the equivalent corresponding thereto, whether previously paid or not, without prejudice to the right of the injured parties, to institute an action for compensation against those who may have caused the deficiency.

"In the second of the cases contemplated above, the granter of the water is bound to join in the action with the employers, should they so desire, and to use every means in his power to assist the same in obtaining compensation from those who had caused the deficiency of water.

"Art. 666. The deficiency of water shall be borne by

those parties during whose period of rotation the said deficiency may occur; saving their right to compensation for injuries, to diminution of water-rent, or its equivalent as above defined.

"Art. 667. Among the different employers, those individuals whose titles or rights of possession are most recent, shall first bear the effects of the deficiency of supply. Among employers equal in the preceding respects, the deficiency shall first affect those whose outlets are at the lowest levels; saving, in all cases, the right of action for compensation against the parties causing the deficiency."

In the preceding articles three main causes of deficiency of supply are contemplated: 1st, Natural causes —as the fall of the level of the supplying river, the destruction of dams or other works by floods or other natural contingencies wholly beyond the control of man; 2d, Neglect of the proprietor of the canal in executing the needful repairs and clearances; and, 3d, The interference of third parties in turning the supply of the canal from its usual course, without the knowledge or the connivance of the proprietor. In the first case very serious injury might result to the employers; their whole harvest might be ruined; but it would be manifestly unfair to make the proprietor of the canal responsible personally for results to which he had in no way whatever been accessory; at the same time, it would be equally unfair to compel the employers to pay for water which they had never received. Hence the arrangement, just to both parties, sanctioned by the first part of Art. 665, whereby the proprietor is absolved from all claims for damages, but is bound to reduce the amount of his annual water-rent in proportion to the extent of the deficiency. It may be true that the proprietor had gone to all the usual expense for the works of derivation; that he had done

everything man could do to insure the supply; that his outlay had, in fact, been very much greater than in ordinary years, having been increased in consequence of his efforts to counteract the deficiency by the execution of extraordinary works: but the broad fact remains, that the employers have not had the quantity of water for which their payments were the equivalents; and to exact those payments where they may not have been made, or to refuse to refund them when they may have been received in advance, would be unjust. The misfortune has been a common one, and it is difficult to say on which party it might fall most heavily; but for either to seek to lighten its weight at the expense of the other, by demands in the one case for services not performed, or in the other for injuries not inflicted, would only be to mix injustice with mishap. The present point merits attention in India, where I think there is much room for improvement in the rules for regulating the remission of water-rent for deficiency of supply in the canals, when this is due to natural causes. There are, in fact, no definitive rules yet established, though it is well known to every one who has had practical experience, that cases to which they would be applicable are very often occurring.

In the second case, the direct personal responsibility of the proprietor of the canal is clear and unquestionable. If he neglects his obligations, or from incapacity fails in fulfilling them, the employers have a plain claim against him, not only for remission of water-rent, but for full compensation for all damages sustained from the deficiency of the supply. The position of the proprietor in the third case is the same as in the first; he has been in no way accessory, directly or indirectly, to the creation of the deficiency, and hence it would be unfair to make him responsible for its effects. The third party by whom the

interference with the supply may have been effected, has caused a common injury to him and to the employers; they have, therefore, their remedy, jointly or separately as may be expedient, against this interfering party, both as relates to the revenue it may be necessary to remit, or the damages which may have been sustained.

The remaining articles regulate the manner in which the deficiency of supply is to be borne by employers among themselves. The arrangements are peculiar to the Piedmontese legislation, and appear to be equitable to all parties concerned. Whatever injuries the most recent or the lowest placed of the employers may sustain under the operation of these articles, are open to redress by the tribunals, either as against the proprietor of the canal or third parties, as may be.

In reviewing the legislative regulations for the measurement and distribution of water in Piedmont, it is impossible to refrain from giving them the highest praise. There is scarcely a contingency which could arise in this complicated and necessarily imperfect branch of the law of irrigation, which has not been foreseen and judiciously provided for. I cannot suppose that I have done full justice to the subject, as it involves subtle questions which have exercised keen legal intellects; but I trust that the practical object of so explaining the principles and details of the various provisions, as to make them clear to those on whom the progress of improvement in the irrigation department of India depends, may have been accomplished. I have no hesitation in expressing my conviction that the various articles examined are worthy of careful study, as containing sound and equitable principles, which, if transplanted to the East, would prove the germs of an orderly and progressive improvement, of the highest importance to the great interest now growing up in

dependence on the irrigation system the English Government is so earnestly engaged in developing.

SECTION IV.

ON PROTECTIVE DISTANCES BETWEEN WATER-COURSES, DISPOSAL OF DRAINAGE-WATERS, EXTINCTION OF SERVITUDES CONNECTED WITH WATER, AND RULE OF SUMMARY POSSESSION.

When an irrigated region is distinguished by a naturally porous and pervious soil, the necessity arises for protecting, by such rules as experience may have shown to be applicable, the rivers, canals, and springs on which the agricultural community are dependent. The provisions for this purpose are now left in Lombardy, as I before mentioned, to be determined for each case by the judgment of professional men familiar with the localities. In Piedmont, the law has decided sundry points connected with this matter; and as we have the same effects of percolation to deal with in Northern India as have been observed in Northern Italy, I now propose to give translations of the articles of the Sardinian code, by which they have been regulated, and, so far as was practicable, prevented from injuring the rights of individuals. There is unquestionably great difficulty in prescribing fixed rules in general terms for questions dependent on the influence of absorption by, or percolation through, the soil—an influence in its nature essentially fluctuating, and modified by numerous physical circumstances. There are probably no two localities where the amount of water absorbed by, or draining through, the land, is precisely the same; every change in the constituents of the soil, every variation of

the proportions between these, differences of slope in the water-courses, and so on, alter the conditions of the problem. Still, experience has shown that there are certain limits within which the effects of the causes just mentioned are practically restricted ; and though this is especially a case where the precise terms applicable to one country cannot possibly be transferred to another, unless the physical elements in both are the same, yet it will be of interest and use to show the manner in which the question has been dealt with in a region which has striking resemblances to that with which we are especially concerned.

The articles affecting protective distances are the following :—

"Art. 599. The ditches and canals which the proprietor of an estate may excavate on his own land, shall be placed at a distance from the boundary-lines of adjoining estates at least equal to their respective depths, except in cases where local regulations prescribe a greater interval.

"Art. 600. The foresaid distance shall be measured from the edge of the bank of the ditches or canals nearest to the boundary-lines above referred to. This bank ought always to have a slope equal to its height, or, in the absence of such a slope, it ought to be provided with retaining works.

"Where the boundary of an adjoining estate is formed by a ditch possessed in common, or by a private road also common, or subject to the servitude of passage, the distance shall be measured from the crest of the bank, as above defined, to the edges either of the common ditch or road nearest to the property of the party desirous of excavating the new canal or ditch ; the obligations regarding the slope or revetment of the channel remaining in full force.

"Art. 601. Should the ditch or canal be excavated in the vicinity of a wall possessed in common, the observance of the foregoing distance is not necessary; but the party excavating the said ditch or canal shall be bound to construct all such intermediate works as may be necessary for the protection of the wall.

"Art. 602. Parties desirous of opening springs, of establishing heads or channels of discharge (*capi od aste di fonte*) for the same, of making canals or water-courses, of clearing, deepening, or widening the beds, of increasing or diminishing the slopes, or varying the forms, shall be bound to observe such increased distances over and above that fixed in the preceding article, and to execute such other works as may be considered necessary for the protection of pre-existing springs, canals, or water-courses, designed either for the irrigation of land or the movement of machinery.

"And in case of dispute between proprietors, the tribunals in deciding ought to aim at reconciling the respective interests of the parties in the manner most just and equitable, having due regard to the rights of property, to the advantage of agriculture, and to the special uses to which the water may be destined. And, further, in all cases where such proceedings may be necessary, they ought to determine and decree, in favour of one or other party as may be right, that amount of compensation which may appear on grounds of justice and equity to be fairly due."

In reviewing the results of experience in Northern Italy on the subject of protective distances in irrigation, we find that the ancient legislation of the Milanese prohibited the excavation of new canals or spring-heads within about 66 feet, or 22 yards, of rivers, and about 580 feet, or 193⅓ yards, of pre-existing springs; that the

regulations of Verona fixed the same distance at 639 feet, or 213 yards; those of Brescia at about 160 feet, or 53⅓ yards; and those of Mantua at nearly 24 feet, or 8 yards. Nothing could illustrate more clearly than these numbers the impracticability of establishing any general rule for irrigated regions of large areas and varied physical structure. The distances range from 8 to 213 yards, the extremes being found in the immediately adjoining provinces of Verona and Mantua. In view of these facts, the legislative body of the kingdom of Italy, formed of rich landed proprietors, intelligent lawyers, and men of science, avoided introducing into the law of the 20th April 1804, any specific distances whatever for the protection of rivers, canals, or springs, but prescribed that in each case the opinions of professional men, nominated by accord between the parties concerned, or in failure of this by the tribunals, should determine the limits best suited to the localities, leaving the right of property in perfectly free action beyond these limits. Article 602 of the Sardinian code follows the same course in principle, with some differences in detail. In all cases whatsoever, the distance between a new and a pre-existing water-course or spring must be at least equal to the depth of the latter, and the channel must either have its banks inclined at an angle of 45°, or protected by revetments of some kind. The upper edge of the bank nearest to the pre-existing water-course is the line whence the above distance is always to be measured. The right of property in water is farther protected by the prohibition, not only of new works, but of any alterations in the conditions of old ones, any changes of slope or variations of form within distances, which in professional judgment might injuriously affect the volumes of existing canals or springs. The tribunals have, however, authority to permit such

excavations or changes, in cases materially affecting the interests of agriculture and industry, but on the condition that just and equitable compensation shall be made for any injury they may cause to the rights and properties of others. The absolute prohibition of the Lombard law is thus modified, with results which, I believe, have proved generally satisfactory; at the same time it is to be noted, that the uncertainty in which the question of protective distances has been left, is a cause of considerable dissatisfaction to the agricultural community. I quote the testimony of M. Giovanetti,* an excellent authority on this point. "The course of legislation and the results of experience," he remarks, "bear witness in favour of our article, but I am bound at the same time to say, that the agriculturists desire greatly the establishment of a maximum and minimum of distances to be observed. They find it hard that they can scarcely strike a spade into their land without running the risk of being summoned before the courts, and forced to give security against possible damages. The proprietors of springs and canals are wearied to death by having to remain always on the watch against the works undertaken by their neighbours, or of having to submit even to real injury, from the difficulty of obtaining clear evidence of it. They do not find an effective protection in the present state of the law. Everybody agrees on the impropriety of excavating new sources of water too near those already in existence, and that the distance equal to the depth of the former is not sufficient for the protection of the latter. But everybody equally agrees that, beyond a certain limit, the proprietor of the soil ought to have free liberty of action. Hence has arisen the idea of a maximum and a minimum of protective distance. Romagnosi lends the weight of his

* *Regime des Eaux*; para. 58.

approval to such a scheme. 'It is admitted,' he remarks, 'that the distance of about 20 metres (nearly 22 yards) is sufficient for the protection of rivers, and, in regions enjoying a vast extent of irrigation, that 8 metres (say 9 yards) is held to be enough for springs and canals. Why should we not adopt these practical results as guides, until farther experiments convince us that they are not to be depended upon?' He states, however, that though these data may be presumed to rest on the foundation of a solid experience, they do not command entire confidence.

"Further experience, the evil effects of contradictory opinions on the part of the professional men employed, leading to heavy and useless expenses, and the observations of many intelligent proprietors, and agriculturists, and of colleagues, whose intellects and doctrines I honour, have converted me to the opinion of Romagnosi. I cannot do better than avow it frankly, and counsel you to combine with our Article 602 the maximum and minimum of the philosopher of Plaisance." *

It is not without a little satisfaction that I quote the conclusion at which M. Giovanetti arrives, since in our humble attempts at legislation for irrigation in India, the principle of this maximum and minimum has been introduced, having been fixed at 20 yards for main canals, and 10 for principal water-courses—limits suggested by the results of our observations on the influence of absorption and percolation on the soil of our irrigated districts.

As the necessary complement to an effective system of irrigation, arrangements for disposing of the drainage-waters connected with it are essential. It will, I believe,

* Romagnosi was born in 1761, at a small village in the vicinity of Plaisance. He early commenced the study of law, for which his genius was remarkable. In 1788, when consequently only twenty-seven years of age, he published his great work on the *Legislation of Irrigation in Italy*, to which I have already referred in Part I.

be found in most cases, and I know from experience it is especially so in Northern India, that imperfections of local drainage, as connected not so much with the great topographical features of the country as simply with irrigation itself, within the limited areas it affects, are more frequently the sources of malaria and injury to the land than anything else. To establish some just and equitable rules on this subject would be of great interest and value; and in illustration of the manner in which the question has been disposed of in Piedmont, I will give the following articles of the Albertine code. They are from the chapter which treats of servitudes arising from the positions of places.

"Art. 551. Lower lands are subject, as towards those which are higher, to receive all the waters which flow naturally, and without the aid of artificial works, from the latter.

"The proprietor of the lower land shall not raise any embankment whereby this escape may be interfered with.

"The proprietor of the upper land shall refrain from doing anything whereby the servitude of the lower may be aggravated.

"Art. 552. When the channels or embankments which serve to contain the waters within an estate are broken down or destroyed, or when variations in the course of the water render defensive works necessary, and the proprietor of the estate fails to restore the channels and embankments, or to construct the required works, then those who shall suffer injury, or shall be in imminent danger of it, can cause the works to be executed at their own expense: they can avail themselves of this power, however, only on the condition that the proprietor of the land on which the works are to be constructed, shall suffer no damage; they ought farther to receive beforehand the permission of the competent authority, to be given

after the parties interested are all heard; and also to conform in all cases to any special regulations which affect the management of the waters.

"Art. 553. The same rule shall apply when it is considered desirable to destroy or remove any obstacle to the free escape of the waters, in the form of deposits or collections of other materials, within an estate, or in a private water-course, the existence of which threatens injury to adjoining lands.

"Art. 554. All the proprietors who have an interest in maintaining the channel and embankments, or removing the obstacles referred to in the two preceding articles, may be called upon to bear their shares of the expense incurred, which shall be rated on each in proportion to the benefit he receives from the works. In every case the proprietors shall have the power of proceeding individually against the party or parties who may have caused the destruction or choking-up of the channels referred to, for the amount of expense incurred, and for compensation for damages caused."

The want of some such rules as the preceding, in the irrigation system of India, is often bitterly felt. The free passage of water is in numerous localities interfered with by the existence of embanked water-courses, which, crossing the natural slope of the country, intercept the drainage-waters, particularly during the season of periodic rain, forming, in consequence, on the upper side, tracts of marsh and swamp, injurious equally to health and property. It was, it is true, a general rule to insist on openings being made through the banks for the passage of drainage-waters to the levels, where natural escape-lines existed; but this rule did not carry with it the weight of a public sanction by the Government, and it was only respected when the canal officers could see them-

selves to its enforcement. In their absence I have known whole villages turn out to resist by force the passage of drainage-waters across their lands; and not without some show of right, for the imperfect operation of the local system merely transferred the mischief from one spot to another, without insuring any radical cure. A comprehensive and authoritative system of drainage in connection with irrigation must be matured, and duly sanctioned by the Government, before the existing evils can be wholly eradicated. The principles adopted in Northern Italy in this matter will be found suggestive; and as there are no physical obstacles of importance to their application in India, I trust they may receive such consideration as may ultimately lead to their being made use of, with, of course, the modifications required to adapt them to a different agricultural system and people.

I may conclude this section by giving the articles of the code which regulate the extinction of servitudes connected with water:—

"Art. 673. The servitude is extinct if it has not been used for thirty years.

"Art. 676. The existence of vestiges of works by which a derivation of water has been effected, is not sufficient to interfere with the above prescription. To prevent its having effect, it is essential that the works connected with the derivation of the water or the channel itself should be maintained continuously in an efficient and serviceable condition."

There are other terms on which servitudes become extinct; but as they are the same as I have already quoted in Chapter I. of this Part, I need not repeat them here.

It is of importance to the public interest that, while disputes regarding rights of water may be in progress

before the legal tribunals, some rules should be adopted for regulating the use of the water during the time required for a final settlement of the points at issue between the parties. In default of these, the water would be lost to agriculture; and to prevent this injurious result, the Sardinian code establishes, in Art. 668, the following conditions:—

"Art. 668. In all questions of summary possession, the practice of the preceding year, and if the servitude be exercised at intervals greater than one year, the practice of the latest period at which it was made use of, shall determine the rights and duties respectively of the party enjoying the servitude, and the party by whom it is due, and of every other party interested therein."

SECTION V.

GENERAL ADMINISTRATION AND POLICE.

The details I have previously given of the general administration and police of canals of irrigation in Lombardy, will render it unnecessary for me to dwell at any great length on like points connected with those of Piedmont, since the principles are the same, and the methods of their application in practice not materially different.

I may first give some extracts from the regulation of the 29th May 1817, by which the administration of the canals continues to be effected:—

"Art. 3. All proprietors, possessors, or employers of canals, supplied by rivers and torrents, are forbidden to execute any works in the beds of the latter without the

sanction of the authorities, under penalty of a fine not less than 10, and not greater than 100 *lire* (from about 8s. to £4), in addition to the expense of replacing things in their original state, and of compensation for any damages which may have been caused to other parties.

" 4. Proprietors, possessors, or employers of canals obtaining their supplies by means of fixed dams, are bound to maintain the positions and forms of these unaltered, to avoid raising their sills, or extending them farther across the beds of the rivers.

" 5. When the supplies are obtained by means of temporary dams, made so as to be easily removed in times of flood, it is forbidden to render such works permanent, or to reconstruct them with heights, or in positions different to those previously in use."

6. Merely repeats the above.

" 7. It is forbidden to proprietors, &c., of canals supplied either by permanent or temporary dams, to make any excavations in the beds of the rivers, whereby the supply would be unfairly augmented.

" 8. Parties violating the foregoing provisions shall be bound to restore things to their former state, and shall, in addition, be subject to a fine not less than 100, or greater than 300 *lire* (from £4 to £12) for each offence.

" 9. When changes in the condition of the streams may render alterations of dams or additional channels of supply necessary, the sanction of the superior authorities must be applied for.

" 10. In such cases the claimant must lay before the intendant of his province a regular plan of the proposed works, prepared by a hydraulic engineer, and showing the part of the river and adjacent lands which will be affected by them, as also the different levels of the same."

Arts. 11 to 13. Instruct the intendant to visit the

spot, or to ascertain, through the agency of the government engineer of the province, that no injury to any one will result from the execution of the proposed works. All parties in the same, or in other provinces or districts, whose interests may be affected by the works, are to be heard for or against them, as may be.

" 14. When, from unforeseen causes, want of water may arise, the proprietors, &c. of canals are authorised, in the event of urgency, to take measures to obviate the same, reporting their proceedings to the intendant of the province, who will cause the works to be inspected; and if they are found to be irregularly constructed, or likely to cause injury to others, will have them removed or altered as may be expedient.

" 15. When changes in the courses of the streams render works necessary, the matter shall be referred to the agency-general of finance; and the intendant-general, having obtained the opinion of the permanent Congress (*of Roads and Waters*), will order the necessary proceedings.

" 16. The proprietors, &c. of canals are bound to maintain all the works in an efficient state, and are personally responsible for any damages to others arising from their neglect.

" They are also bound to provide for the free escape of surplus-water in time of flood, under penalty of a fine varying from 10 to 100 *lire*, in addition to giving compensation for damages."

17. 18. Extend the above.

" 19. Siphons for the passage of waters belonging to private parties beneath the beds of streams, shall be maintained unaltered by their proprietors; and they are forbidden to execute any works connected with them, which might contract the sections or raise the beds of the rivers, under pain of a fine not less than 30, or greater than 150

lire, in addition to the expense of restoring things to their original state."

20. to 24. Prescribe conditions to proprietors of siphons under streams, binding them to permit these to be altered, as the government engineer may consider necessary, with reference to the protection of the public rivers.

The next administrative regulation which contains points of interest bears date the 10th of September 1836; and from this a few characteristic extracts may now be given.

"REGULATION for the ADMINISTRATION of the ROYAL CANALS of IRRIGATION.

"CHAPTER I.—*Of the Maintenance of the Canals.*

"Art. 1. All the royal canals of the kingdom are subjected to the present regulation.

"2. The general control of the royal canals is vested in the agency-general of finance, the executive duties being performed by engineers and guards appointed by it.

"The latter, with the guards appointed by the farmer of the canal revenues, shall take an oath of fidelity in presence of the judges of their respective districts.

"3. The engineers and guards are charged to prevent all injuries to the waters, works, and employers of the canals.

"4. The articles of the regulation of the 29th of May 1817 are maintained in full force.

"5. No one, unprovided with a legal grant or title, can make any use whatever of the canals; and any interference with the free course of the waters, in the main channels or branches thereof, is forbidden. Violations of any part of this article shall be punished by a fine of from 50

to 150 *lire* (from £2 to £6) for each offence, in addition to compensation for damages.

" 6. Parties having a legal grant of water, but taking more than the quantity they are entitled to, or using it at a different hour from that specified in the agreement among the employers of a common channel, or violating in any other way the terms of their grants or agreements, shall be subject to a fine of from 50 to 100 *lire* (£2 to £4), in addition to compensation for damages.

" 7. Whoever shall raise or lower the gates of the outlets or escapes, alter, break, or deface the chambers of the works of measurement, force the locks of the same, or change their dimensions, shall incur a fine of from 150 to 300 *lire* (£6 to £12), in addition to the amount payable for damages.

" When the offence is perpetrated on crown property, the pecuniary fine shall be accompanied by imprisonment for a period varying from one to six months.

" 8. Employers of the canals shall maintain their irrigation outlets and channels in the forms prescribed by their grants, under a penalty of from 50 to 100 *lire*.

" 9. The water flowing from irrigated lands, commonly called *coli* (*colature*), shall be permitted to enter the canals freely, except when special agreements to the contrary have been entered into, under a penalty of from 50 to 100 *lire*, in addition to the price of the waters intercepted.

" 10. It is forbidden to fish in the canals, or to excavate sand from them, or to use boats on them at any time, under a penalty of from 10 to 30 *lire*.

" 11. The agency-general of finance may permit fishing, navigation, or excavation of sand, having first procured the opinions of the engineer and the director of the domain."

"Such permission ought to indicate clearly the portion of the canal to which it applies; it can be granted only for a period of not longer than one year, and is null and void unless registered by the grantee at the office of the direction of the domain, and of the local secretariat of the province.

"12. It is forbidden to establish, without the authority of the agency, bridges, fords, or ferries, and also to cross the canals, either on foot or with cattle, under a penalty of 10 *lire*, in addition to the expense of destroying works executed in contravention of this article."

13. Repeats the above.

"14. Whoever takes possession of land along the canals which belong to the royal domain, removes the land-marks, makes excavations, carries away the produce of the plantations, or traverses the banks with cattle, carts, or conveyances of any kind, shall incur a fine of from 5 to 10 *lire* for each offence, in addition to the repair of any damages which may be caused, or to the cost of the things carried away.

"15. The possessors of land fronting or adjacent to the canals are forbidden to open new springs, to excavate ditches, to form ponds, water-courses, or channels of any kind, within a distance of 200 metres (nearly 220 yards) from the said canals, except in such cases as may be specially decided upon by the engineers, who will then fix such distances as may seem to them sufficient to prevent any leakage of the waters of the canals into the works referred to.

"It is also forbidden to the aforesaid possessors of land to plant trees within a distance of 3 metres (about $3\frac{1}{4}$ yards) from the boundaries of the canals. Infringements of this article shall be punished by a fine of 10 *lire*.

"16. It is forbidden to cut the trees on the canal

banks, or to carry away the prunings of the same, under penalty of a fine equal to double the value of the trees or prunings.

"If the trees cut and carried away shall exceed the value of 25 *lire* (about £1), the offender shall be imprisoned for not less than one month, in addition to paying the fine as above.

"17. Parties acquiring by legitimate titles any right to the plantations along the canals, shall not be allowed to cut or prune them except at the times and to the extent specified by the engineers in charge.

"18. All parties are forbidden to pasture cattle on the banks of the canals at any period of the year, under a penalty of from 1 to 3 *lire* for each animal."

The second chapter of the regulation, from which the preceding articles have been quoted, is occupied entirely with details of the legal measures to be followed in prosecuting offenders. They are of no interest to us, being purely local in their character.

The agency-general of finance published, under date the 30th September 1838, a very elaborate series of instructions for the guidance of all the officers connected with the royal domain in its various branches—for the officers of the canals among others. An abstract of these will give a good idea of the organisation of the personal establishments of the canals; and I give it here, freed, however, from a number of petty details, which can be of very little use to any one.

In section first, the duties of the director of the canals are defined. He has the general control of the executive department; the engineer-inspectors, and assistants in charge of the different canals receive all their orders from him, and through him they communicate with the agency-general of finance.

Art. 591 of the instructions is to the following effect :—

"The charge of the royal canals is vested under the superintendence of the Financial Department, in a director, engineer-inspectors, assistants, and guards." The subsequent twenty-five articles detail the duties of the first-mentioned of these officers. He settles all matters connected with the works, the plantations, the revenues, and the lands belonging to the canals, except when special provisions are made to the contrary. He is vested with power to proceed against all parties who have taken illegitimate possession of the canal waters, or, having legitimate rights to these, have improperly extended the same; he also enforces the police regulations for the protection of the works of the canals. All projects for works prepared by the various engineer-inspectors are first submitted to him, and, after examination and approval, are transmitted by him for the consideration of the financial department. Projects for new works must be forwarded at the beginning of August, and those for the ordinary repairs of the canals not later than the end of September of each year, so as to admit of their being duly sanctioned and executed before the commencement of the season of irrigation. The director's report on any project is invariably to be accompanied by a nominal roll of the executive engineers and assistants to whom the works are to be intrusted, and the qualifications of the individuals are to be carefully noted. On receiving the specifications and estimates for works duly approved of by the Agency, the director furnishes copies of these to the engineer-inspector in charge, who advertises for contractors to execute them, it being absolutely prohibited, except under circumstances of pressing necessity, to construct any works by daily labour. The plans and estimates being once approved of by the Agency, the director is bound to take care that no

changes are introduced without revised plans and estimates having first been submitted. Art. 604 enjoins the director to take every opportunity of inducing parties to regulate their outlets, and to introduce a uniformity of distributing and measuring arrangements throughout the canals.

Art. 607 requires the director to submit annually to the agency of finance a detailed report on the canals, embracing the following particulars :—

1st, The quantity and quality of trees and underwood in the canal plantations ready for cutting, with a statement of the probable expense required to keep the plantations in good order.

2d, The condition of the various works, with suggestions for their improvement or extension.

3d, The volume of water in each canal, and the means of increasing the same for the benefit of agriculture.

4th, The number, positions, volumes, and state of all the existing outlets of irrigation, whether from the main lines of canal or from secondary branches, distinguishing those held under perpetual grants from such as are held by leases ; the dates of the deeds of grant or leases, the amount of rent due, the districts in which the irrigated lands are situated, and their area, at least by approximation, if actual measurement cannot be made. When the director has once prepared this report with all possible exactitude, he is permitted by Article 609 to limit his subsequent annual reports to a notice of the variations which may have been made in its details during the year to which he may be referring.

Articles 610, 611, and 612, refer to the collection of sums due to the royal treasury, and to the employment of such mills or manufactories as are worked on account of the State. The director is enjoined to take care that the latter are rented to substantial tenants at fair rents,

and that they are maintained in constant work. When important matters may require his presence, the director is instructed by Article 613 to proceed at once to the spot, and to direct the proceedings in person. Articles 614 to 618 are devoted to details of the organisation of the director's office, to the manner of keeping the accounts and records of all kinds lodged there, and to other minor points which possess no special interest.

The second section of the instructions is occupied with details of the duties of the engineer inspectors and their subordinates. Article 619 states that the engineer-inspectors, assistants, and guards, are under the orders of the director; they rank with each other in the order of their respective grades, and they will reside in the places specified in their brevets of destination. The engineer-inspectors are enjoined in Article 620 to maintain a constant correspondence with the director on all points connected with their duties, and to communicate directly with the agency only in case of extreme urgency. When such communications are made, information of them must at the same time be sent to the director. The engineer-inspectors are required by Article 621 to inspect every part of the canals under their charge, twice a-year at least; viz., 1st, at the time when the annual estimate for the ordinary repairs is being framed; and 2d, when these repairs are in process of execution. If circumstances render it necessary, visits at intermediate times are to be made, and all projects for new works are to be transmitted to the director before the end of July of each year. Estimates for annual repairs must be submitted during the first fifteen days of September. Articles 626 to 629 prescribe rules for the preparation of plans, specifications, and estimates, which need not be detailed, as they are in no way remarkable.

Article 630 is to the following effect:—

"All irrigation outlets, large or small (*bocche e bocchetti*), shall be maintained in an efficient state, at the sole charge of the individuals or communities using them.

"In all cases, however, where neglect or delay in executing repairs to these works appears likely to influence their discharges, the engineer-inspectors are enjoined to annex to their annual estimate a statement for each separate canal, indicating the extent and probable cost of the repairs required by the outlets referred to. If the proprietors of these should refuse to execute the works required, the engineers are authorised to do so, on the terms of the estimate framed by them, and the amount shall be recovered from the employers."

Article 631 forbids the executive officers to allow any alteration of the dimensions of outlets, without the order in writing of the agency or the director.

Articles 632 to 636 prescribe rules for contracts, for survey reports, and measurements on the completion of works, for weekly reports of progress, and other matters of detail common to all public departments. The guards are required by Article 637 to devote their entire time to their duties, but they are not to be employed beyond their own districts.

Powers to proceed to the summary execution of repairs or works in emergent cases are vested in the engineers by Articles 638 to 642, and instructions regarding the documents to be submitted to the agency, on the completion of such works, are given. The engineer-inspectors and assistants are required to keep journals of work done by them, which are to be forwarded monthly to the director, and by him to the agency. Article 650 formally prohibits the engineers or their assistants from undertaking works for private individuals, on pain of

dismissal from the service; and in the last article of the series it is ordered that they shall obtain the sanction of the agency before accepting of any commissions for works either from communal or other public bodies.

The preceding summary of a very long document will suffice to show the general organisation of the canal department in Piedmont. The duties of the different members of the personal establishment are very much the same, so far as the works are concerned, as on our own canals of irrigation in India. The superintendents of the latter, however, have revenue and police, as well as executive duties, intrusted to them; and I have already expressed my opinion, that this system has produced better results than the disjointed plan adopted in Northern Italy.

As regards the administration and police of private canals, I have very little to say. When the canals are the property of associations, they are governed by representative councils, elected, as in Lombardy, from the main body of the employers. Each council has its own regulations, sanctioned by the administrative authority, and adapted to the circumstances of each locality. They conform in principle to the rules for the public canals, and present no features of special interest. When canals belong to individuals under ancient grants, the administration is conducted by them under the same checks as for associations. The legislation of irrigation is now so complete in Piedmont, that infringements of the respective rights of employers and proprietors of the waters are duly provided for; and to perfect the view of the protection afforded to these, I may give, before quitting the present subject, those provisions of the penal code of Sardinia, which have for their end the punishment of crimes against property in water, or works connected therewith.

Extracts from the Sardinian Penal Code.

"Art. 711. Whoever shall have voluntarily destroyed, cut, or broken through the dikes or embankments constructed for defence against the rivers, streams, or torrents, and shall have caused thereby an inundation, in which one person has perished, shall be punished by death. If, however, this person has perished under circumstances which the offender could not possibly foresee, the punishment shall be that of hard labour for life.

"In every other case the punishment shall be forced labour for certain periods, or, in lieu thereof, separate confinement for seven years at least.

"Art. 712. If the destruction or rupture of the dikes and embankments, or like works alluded to above, shall be attributable to a simple fault, the punishment shall be that of imprisonment.

"Art. 713. As regards other breaches or injuries done or caused to dikes, embankments, bridges, hydraulic buildings, or other works of art, including such as belong to private parties, the punishment shall be that of separate confinement. The tribunals may, however, in consideration of the circumstances and the nature of the injuries, substitute for the preceding the punishment of simple imprisonment.

. . . . . .

"Art. 718. Every individual who, without right, or by means other than those above indicated, shall voluntarily cause waste, damage, or deterioration on the lands of others, ...
whether by levelling or filling up ditches or canals, shall be subject to the penalties specified below.

"If the damage done shall exceed the value of 100

lire (about £4), the punishment shall be three months' imprisonment at least.

"If it does not exceed this value, the punishment shall also be imprisonment, of which the period may be extended to six months.

"In the two cases referred to above, the tribunals may add to the imprisonment a fine, which shall in no case be less than one-half, or greater than twice the amount of the damage done.

. . . . . .

"Art. 723. He who, without title, and without right, shall take water, or cause it to be taken from any reservoir, or from rivers, streams, torrents, rivulets, springs, canals, or water-courses, and shall appropriate it to any use whatever;

"He who, to the same end, shall break, or cause to be broken, the dikes, dams, sluices, or other like works, existing along the rivers, streams, torrents, rivulets, springs, canals, or water-courses;

"He who shall hinder in any way the exercise of rights which other parties may have acquired to the said waters;

"He who, finally, shall usurp any right whatever on the sources of water referred to above, or shall trouble any one in the enjoyment of the legitimate possession he may have acquired,

"Shall be punished by imprisonment, the period of which may extend to one year—and by fine, the amount of which may be carried to 500 *lire* (nearly £20).

"The tribunals have the power of inflicting separately one or other of these punishments.

"Art. 724. If individuals possessing a right to obtain or use water shall fraudulently cause their outlets, dams, or channels, to be constructed in forms different to those agreed upon, or having capacities of supply greater than

those to which they have right, shall be punished as guilty of abstraction of water.

"Art. 725. The proprietors, farmers, or other employers, who, in using their legitimately acquired rights to water, shall cause it to overflow the roads or lands belonging to others, shall be punished by a fine, which shall not exceed one-fourth of the amount of the damage done.

"Art. 726. If the crimes contemplated in the present chapter shall be committed by the guardians of woods and waters, or by any other public agents, whose duty it is to check or prevent them, the punishment of imprisonment, when inflicted, shall exceed by one month at least, and, at most, by one-third of its duration, the heaviest penalty inflicted on individuals not public agents, who may have been guilty of the same crime, provided always that the maximum of punishment fixed for the said crime shall not be exceeded."

It will be remembered that in all cases of injuries done to the rights or the works connected with irrigation, the civil code has granted the power of proceeding for compensation against the parties to whom such injuries may be attributable. The penal code provides for the cases in which fraudulent intent, malice, or criminal neglect are involved. Water in irrigating countries is, in truth, one of the most valuable articles of property a man can possess. It is just as great an injury to him to steal his water, as to steal his money or goods; and the one ought certainly to be not less carefully protected than the other.

There is great room for improvement in the department of penal legislation on the canals of Northern India; and the details now given will, I venture to hope, lead to a consideration of the subject.

SECTION VI.

SANITARY LEGISLATION.

During my residence in Turin at the beginning of the present year, the senate of Sardinia was occupied in discussing the project of a law for the regulation of rice-cultivation in its relations to the public health. I followed the debates with much interest, and was glad to find that reasonable and practical views of the question were generally taken. By the kindness of Chevalier Marioni, intendant-general of finance, I was supplied with a copy of the report* of the commission of the senate appointed to examine the project; and as this gives an interesting historical summary of the sanitary legislation of Piedmont, I cannot do better than borrow from it some of its more important details.

In their introductory remarks, the commission take a sound view of the foundations on which any legislation on such a question as the present should rest. "A good law on the culture of rice," they observe, "which, while it respects the rights of property, and promotes the interests of agriculture and commerce, shall prove a safeguard to the public health—a law such as the nation desires and the Government would wish to present to parliament, so as to terminate at once and for ever the evils and uncertainties growing out of the existing state of our legislation —cannot possibly be prepared without a collection of

* "Relazione dell' Ufficio Centrale composto dei Senatori Moris, Marioni, Guilio, de Cardenas, Cotta sul progetto di legge provvisoria sulle Risaie," dated 20th February 1851.

statistical facts far more extensive and accurate than any we now possess. It is from these alone that the principles of such a law can be deduced with confidence, that the means of enforcing its provisions can be ascertained, and that the necessities which justify it can be made apparent not only to the legislature but to the proprietors, on whom it imposes restraints and cautions, and to the population whose means of subsistence and health it peculiarly affects. To attempt final and definitive legislation in the present state of our knowledge, would be to give way to an inconsiderate and ill-informed desire for improvement, and would derange established customs by the substitution of others having no true elements of stability, and destined after the lapse of a few years to be replaced by the results of longer experience and larger knowledge.

"A vast quantity of writing and speaking has been expended on the question of the insalubrity of rice-cultivation. But the argument is wide in its extent and varied in its relations, and the parties who have discussed it have hitherto concerned themselves less in the careful collection and examination of well-ascertained facts, than in the development of preconceived opinions and popular prejudices. Hence it is really impossible to satisfy the public mind, by a clear definition of the true conditions by which the evils accompanying the culture of rice are influenced, or to point out the means whereby the law could best eradicate, or at any rate diminish, the intensity of such evils."

From these views of the commission I believe no one will be disposed to dissent. If rice-cultivation is to be interfered with at all, it is only just to all parties concerned that the interference should be an intelligent one, based on facts honestly obtained, and interpreted as clearly as our present knowledge will permit. As this

cannot be the case in Piedmont, the existing legislation is purely provisional.

The earliest important act of sanitary legislation dates from the close of the year 1608, when Carlo Emanuel I., duke of Savoy, prohibited the sowing of rice in any part of the kingdom, except by license under his sign-manual, sealed with the great seal, sanctioned by the chamber of accounts, and adverting especially to the following conditions—viz., that the land should be unsuited for any other form of cultivation; that it should be at a distance of 4½ English miles from any town or village, and 650 yards from any road; that the license had been granted with the consent of two-thirds of the heads of families in the commune, and with the engagement on the part of the holder to secure perfect drainage for the water, and to maintain the necessary number of bridges for cross-communication. The duke foresaw the storm that would arise from the enforcement of his orders, and, as though distrusting his power to withstand it, he declared that licenses granted in terms contrary to those just established were *ipso facto* null and void, though given by himself, and containing clauses specially permitting the infringements. These precautions, however, met with little success. "Complaints *rained down* upon him," says the reporter of the commission, and the duke handed them all over to the chamber of accounts, under whose auspices the granting of licenses for rice-culture became before long an important source of revenue. The payment at first was a tenth part of the gross produce, but this was subsequently commuted in 1621 to a tax of one ducat (nearly 5s.) per *giornata*, which is very nearly equal to an English acre. It might have been expected that a burden so considerable on the land under rice would have checked the extension of the culture; but neither this nor the

renewal, at various times during the course of the seventeenth century, of the different provisions of the act of 1608, seems to have had any decided effect. The cultivation continued to spread, and by the middle of the century had become firmly established in the provinces of Vercelli and Biella, the districts of Borgaro, Legni, Cumiana, Orbassano, Rivolta, Piossasco, and Parpaglia, with a number of others specified by the commission.

In the hope, perhaps, of obtaining more by asking less, the edict of the 21st March 1663 limited the protective zone to 4½ miles round Turin only, to 3 miles round Vercelli, to 900 yards from other inhabited places, to 30 yards from houses, and to 75 on each side of the public roads. Very soon afterwards, however, the law returned to its ancient severity, and on the 28th April 1667, rice-culture in the districts of Borgaro, Settinio, Legni, Caselli, and Volpiano, was absolutely forbidden—the chamber of accounts, however, retaining the power of granting special licenses. Two years later the chamber received peremptory orders to destroy all rice-culture wherever they thought it mischievous. During the course of the succeeding year (1669) the war against the unlucky rice-proprietors waxed faster and more furious. The protective zone round Turin was increased to nearly 14 English miles! all rice-lands established since 1660 were doomed to destruction throughout the whole kingdom, with exceptions in favour of those parties who had rigidly observed the conditions of the edict of 1608; lands under rice, but within a distance of 3 English miles of towns or walled places, and of 1½ miles from any inhabited places, were also to be otherwise employed; and no rice-culture was to be established in localities where perfect drainage did not exist—that is, in marshes or like tracts of country; and, finally, the proprietors were ordered to renew annually

their registered obligations to insure the free flow of the water, and to maintain the drainage and other works in an efficient condition. The result of these severe measures was the gradual diminution and ultimate extinction of rice-cultivation in a considerable portion of the upper districts of Piedmont. But in the special region of irrigation in the province of Vercelli, no prohibitory enactments could check the progress of the culture. In 1697, Vittorio Amadeo II. issued an edict under date the 20th of January, forbidding rice-lands within 9 English miles of the towns in this region. The chamber of accounts remonstrated vigorously against this order. They represented to the duke that the natural sterility of the soil, except for rice-culture, the numbers of springs, the marshy nature of the localities, the want of capital, the scanty population, the character of the proprietors of the rice-lands, would present serious and probably insuperable obstacles to the execution of his edict, and they recommended the modification of its terms. Their advice, however, was neglected, and the law remained in force until 1728, when it was again modified. The conditions at this time attached to the culture were the following :— All rice-lands established after the year 1710 were to be destroyed or applied to other uses, and no new cultivation was to be undertaken except in the districts specified in the edict. The legal distances were established as follow :—

From the city of Vercelli, ...	6½ miles.
From the towns, ...	900 yards.
From farm-buildings, ...	80 „
From royal and public roads, ...	75 „

It is wearisome to trace the perpetual fluctuations of this most variable legislation. A single year had not elapsed before the king again introduced new rules. He

absolutely prohibited the culture in some fifteen or twenty districts of the provinces of Biella and Vercelli, which were in every way well adapted for it. Of course, the orders were treated with neglect, and in 1733 it was found necessary to depute a commission of professional men to examine the objections expressed on all sides to them. In the following year the terms were rendered less severe, the protective zone round Vercelli being reduced to 4½ miles in breadth, and for other places to 600 yards, while special licenses were granted in great numbers.

The state of the question in the Lumellina and the province of Novara, where rice-culture early took root, may now be noticed.

In the Lumellina, the supreme magistracy of the province established by an edict, under date the 25th October 1713, the following protective distances :—

For the town of Mortara, ...	1800 yards.
For towns containing more than 100 houses, .	450 „
For places having 50 houses, ...	200 „
For any separate building, ...	25 „
For royal roads, ...	100 „
For main roads, ...	50 „

The same edict forbids rice-culture in marshy localities, where free drainage does not exist.

Fourteen years afterwards, the intendant-general of Alessandria and the Lumellina fixed the legal distance at 600 yards for all places indiscriminately; but as the enforcement of this order was found to be perfectly impracticable, from the universal resistance offered to it by the agricultural community, a new edict, under date the 25th April 1728, established a specific distance for each inhabited place throughout the province, dependent on local peculiarities. These distances varied from 600 to 50 yards, according to circumstances. It was ordered that

the legal distances should be marked for each place by four boundary pillars at the cardinal points; and power was given to the inhabitants to prevent rice-culture, even beyond these limits, if more than two-thirds of the heads of families should object to it. These would seem to be the latest regulations specially applicable to the Lumellina.

The earliest provisions for the province of Novara are supplied by the edict of 1682, confirmed in 1708 by Prince Eugene, then governor of the duchy of Milan (to which Novara was at the time attached), and maintained in vigour when the possessions of the house of Savoy were extended to the right bank of the Ticino. By the edict referred to, the protective distances were fixed as follows:—

For the town of Novara, ...	2600 yards.
For places having at least 100 houses, . . .	325 „
For places having at least 50 houses, . . .	150 „
For smaller places, and for every separate and inhabited house,	25 „

The last acts against the extension of rice, prior to the establishment of the dominion of the French, were the patents of the 3d August 1792, and the 25th January 1793, by which the introduction of new rice-lands into the provinces of Novara, Vigevano, Lumellina, Vercelli, Biella, and Casale, was prohibited, while the proprietors of existing rice-lands were required to present their licenses for examination within three months, and to furnish details regarding the position, the area, and the distance from inhabited places and roads, of their respective properties.

Very soon afterwards, some of the most important of the provinces just mentioned were attached to the Cisalpine Republic (subsequently the kingdom of Italy), of which the Sesia was made the boundary on the westward. Hence the Lombard legislation, to which I have pre-

viously referred, became temporarily applicable to them. The sanitary law of the 9th February 1809 regulated rice-cultivation till 1814, when the king, Vittorio Emanuel I., on the old boundaries of the kingdom being restored, re-established in full force the patent of 1792. As the cultivation, however, had continued to extend during the interval, it was found necessary to sanction the continuance thereof in all places where, according to the judgment of professional men, the land was unfitted for other use, or where the existence of rice could not affect prejudicially the public health. In 1815, a special commission was organised to examine the entire question. The first act of this body was to grant its sanction, under date the 10th of June 1815, to all rice-lands actually existing at that period; maintaining, however, the protective distances round the towns established by the ancient legislation. It must, however, be noted that the observance of the letter of the law was very imperfect, for in all cases where a certificate from qualified professional men was granted to proprietors in favour of their rice-lands, the commission at once sanctioned their establishment. In 1828, a tabular statement of the rice-lands of the kingdom was prepared, showing their areas, positions, and distances from inhabited places, but no special measures seem to have followed; and in 1835 the commission was abolished, its functions being transferred, first, to the magistracy of health in Turin, and subsequently, in 1838, to the similar tribunal of Casale. From that time forward, up to 1851, I do not find any legislative acts affecting irrigation.

The commission of the senate remarks on the preceding summary: "Three conclusions appear to us to be clearly deducible from the rapid review just given of the laws affecting rice-cultivation, which have grown up among us

during the course of two centuries and a half. First, that the sole remedy against the insalubrity of rice-irrigation, which has been thought of and applied in practice, has been to keep it at a distance from inhabited places; but that the limit of this distance has been increased or diminished in a manner wholly arbitrary, and without reference to any theoretical principles or experimental results which warranted the terms selected. We say this was the sole remedy, because, although the laws ordain that free passage shall always be insured for the water, no specific plans for drainage were either suggested or enforced; and the districts where rice-cultivation prevails, remain still unprovided with this important means of securing their salubrity.

"The second inference, which appears to the commission no less clear than the first, is, that a remedy which has been altered incessantly, and at brief intervals, cannot be regarded as a successful one, since it must have failed to produce the results anticipated from it by those who tried it in various forms.

"Thirdly, it is clear that, throughout the entire progress of our legislation, it has always been found necessary, in endeavouring to limit the extension of rice-irrigation, to respect the interests which had grown up even in spite of the laws, and to sanction the continuance of the culture in places where it had been established for considerable periods. Illustrations of this necessity are given especially by the edicts of 1728, 1792, and 1809; and when the contrary course has been adopted, as in 1674, 1697, 1729, and 1815, the discontents and difficulties created have been such as invariably to force the Government to modify its orders, and to admit so many exceptions, as, in point of fact, rendered the laws nearly inoperative.

"If, therefore, the ancient laws do not supply examples of successful remedies which we can imitate—if, farther,

the facts on which a definitive law could be founded so as to secure the confidence and respect of all parties concerned, do not at this present moment exist, the commission is of opinion that measures should be taken to collect such facts, and that all attempts at definitive legislation should be deferred until this preliminary inquiry has been satisfactorily completed.

"On the other hand, the commission is distinctly of opinion that certain conditions should be attached to the formation of new rice-lands; and, pending the collection of facts on which a definitive law can be based, they think that a temporary measure may properly be sanctioned. They, therefore, recommend that the project now submitted be passed by the senate, with the modifications which have been suggested by the commission."

In this, the latest example of sanitary legislation on irrigation in Piedmont, the old remedies, and the old recognition of infractions of previous enactments, are re-established and submitted to. A distinction is admitted between rice-lands formed *before* and *after* the year 1848, and the law is much milder in its provisions regarding the former than the latter. By Article 1, all rice-lands formed after 1848 within districts or protective zones round inhabited places, as defined in previous acts, are positively prohibited, and are ordered to be destroyed or turned to other uses before the close of the current year. With the view of preventing the lands thus abandoned becoming noxious to the community, the project of the commission imposes on their proprietors the obligation of executing and maintaining such works as may be necessary to secure the free passage of the water which had been introduced for the purpose of irrigating them.

Art. II. provides that other rice-lands similarly situated within prohibited limits, but formed anterior to 1848,

shall not be interfered with, unless their effects have proved prejudicial to the public health. The proprietors of such lands are bound to submit to the syndics of the communes within which they are situated, within fifteen days from the passing of the act, detailed surveys (*consegni*) of them. These surveys may be executed on unstamped paper (*carta libera*), and should show the extent, position, &c., of the fields.

Art. III. directs the syndics to submit these surveys for the consideration of the communal councils, and requires the councils to verify the same, and to cause any deficiencies of information to be supplied within fifteen days from the time of their receipt. The tabular statements founded on them are to be published repeatedly in the communes, so that parties having objections to the continuance of any of the rice-lands may be heard against them.

Art. IV. All parties having objections, on sanitary considerations, to any of the rice-lands referred to in Article II., shall present proofs of the same in writing to the intendant of the province, or to the intendant-general of the division in which the said lands are situated, within ten days from the last publication of the surveys.

Art. V. prescribes the times within which the intendants are to forward to the intendants-general the objections submitted directly to them. The commission proposes two days being allowed for this purpose.

Art. VI., as modified by the commission, is to the following effect :—" The intendant-general shall communicate immediately with the proprietors of the rice-lands against which objections have been made through the syndics, and shall require these parties to reply to such objections within five days. The intendant-general, taking into consideration the observations on both sides, and having heard the opinion of the provincial council of

health, shall decide definitively within fifteen days whether the lands objected to shall be tolerated until the promulgation of a general law on rice-cultivation, or for the current year only, or be converted at once to other uses, with the exceptions specified in the succeeding article.

" Art. VII. In addition to the rice-lands to which objections are found to be irrelevant, the following shall be tolerated until the promulgation of a law to the contrary: all lands to which no objections had been raised; those established without special licenses, but in districts or zones not prohibited; and those, finally, which, though established in districts and zones under prohibition, have received the sanction of Government at any former time.

" Art. VIII. On the other hand, rice-lands under the following circumstances are prohibited, and the cultivation of them ought to terminate at once either by the act of the proprietors, or by official interference directed by the intendants-general, and at the expense of the proprietors: 1st, All rice-lands formed subsequently to 1848 in prohibited places; 2d, Those previously established in like localities not duly surveyed and registered; and, 3d, Those which the intendants-general may consider prejudicial to the public health."

Such are the terms of the project; and to facilitate their execution, the commission recommend the preparation by the Government of a table, showing the districts and distances within which rice-culture is permitted by previous legislation, for the guidance of all parties concerned. What the final fate of the proposed law has been, I have not had an opportunity of learning, but there seems no good ground for expecting it to produce any better results than its predecessors. The agricultural proprietors are in direct opposition to the Government—means are invariably found, first, to evade all the rules the latter may issue

—and, in the end, to compel the regulating authority to recognise such evasions, by sanctioning what it has proved incompetent to prevent. The cultivators of rice have, with every new law, secured the occupation, as it were, of a new province ; and the whole history of the progress of the sanitary legislation of irrigation in Northern Italy has been a record of successful encroachment on one side, and vain efforts at repression on the other. " I persist in the opinion," says M. Giovanetti, " that the provisions established for keeping rice-lands at a distance from cities, towns, and villages, are dictated by incorrect notions,* and the passion for regulation-making. In Milan, in Venice, in Piedmont, in the States of the Church, everywhere, in short, they have adopted the same measures. It is a struggle which has lasted for centuries between the agriculturists and the governments, and in these times it seems to be recommencing. What strikes me as most singular in the matter are the flagrant inconsistencies of the governments themselves. They encourage in all possible ways the establishment of canals, and have incurred enormous expense in executing them : in all time the people with us cluster, as if by instinct, near the rivers and water-courses, and the governments think fit to throw serious obstacles in the way of utilising the waters for agricultural purposes. What is worse still, the regulations have ended in becoming instruments of arbitrary power, and of low and detestable passions. There is scarcely a dispute on the present subject which does not owe its rise to intrigue or ill-will on one part or the other.

" For my own part, I regard the absolute prohibition of the culture as far more logical, and much less mischievous to the interests of the community, than these everlasting

* As will presently appear, our experience in India is somewhat opposed to this opinion.

skirmishes between prohibitions and permissions. It is not that the abolition of rice-lands has proved effective in ameliorating the air where this has been tried, for the remedy has, in my own experience, proved inadequate; but by so proceeding, the state of feverish uncertainty and anxiety, which is a curse to agriculture under the existing system, would, at any rate, be put an end to.

"I do not, however, advocate the abandonment by governments of their right of surveillance over rice-culture, and every other form of agricultural or industrial occupation, which is held to be injurious to the population of the states they rule; but I do say, that our past legislation has been an error and an evil in the changing shapes it has assumed, and that our laws, to be respected, must rest on sounder foundations than they now possess."

To this conclusion all experience tends, and it will, I am sure, command the full consideration it merits in any efforts which may be made to establish sanitary regulations for the irrigated districts of India. I shall have occasion presently to refer to the sound measures already adopted, to secure a broad basis of facts on which to found the rules to be enforced. No one will question the extreme difficulty and delicacy of the question. The mysterious nature of the morbific principle or principles, which we include under the general term of malaria, and our ignorance of the laws of its distribution, or the limits of its influence, embarrass our progress. It is like carrying on a campaign without an intelligence department. On the other hand, the great interests of agriculture, the importance of leaving these as free to expand as possible, and of saving them from the blight of uncertainty or harassing interference, require profound caution, lest, in our respect for sanitary considerations, we overlook, or, it may be, inflict injury on others of certainly equal value to the general good.

CONCLUDING REMARKS

ON THE LEGISLATION OF IRRIGATION IN NORTHERN INDIA.

THE comparatively recent establishment of the great canals of irrigation, executed by the British Government in Northern India, and the absorption of the attention of the officers connected with them in the primary duties of completing the works, and organising the material details of the system, have hitherto interfered with the progress of legislation, and hence there is but little to show on this branch of the subject. It appears to me, however, that I cannot better conclude my work than by placing on record the efforts that have been made, all imperfect as they confessedly are. By thus supplying the means of comparing them at once with the matured results of the long experience of Northern Italy, as given in the preceding chapters, it may be that their deficiencies will be better indicated, and the means of improving them more clearly suggested, than by any comment I could make.

A single act of the legislature of India, under date the 12th April 1845, embodies our existing legislation of irrigation. It is to the following effect :—

"ACT No. VII. of 1845, passed by the GOVERNOR-GENERAL of INDIA in Council, on the 12th of April 1845.

"*An Act for regulating the levy of water-rent, tolls, and dues, on certain canals for irrigation and navigation, constructed by Government in the North-Western Provinces, and for the protection of the said canals from injury.*

"Whereas numerous canals have been constructed, and are in progress of construction, at the public expense, in the north-western provinces of the presidency of Fort-William in Bengal, for the purpose of irrigation, and also for navigation, so far as it may be practicable to unite the two objects; and whereas it is requisite to regulate the levy of rents, tolls, and dues on such canals, and to provide for their protection from injury—

"I. It is hereby enacted that the lieutenant-governor of the north-western provinces shall be competent, by proclamation to be made in the Government *Gazette*, to declare the provisions of this act applicable to any such canal.

"II. And it is hereby enacted, that the said lieutenant-governor of the north-western provinces shall be competent to draw out rules to regulate the levy of water-rent, and the supply of water for irrigation, and the payment of tolls and dues on boats, rafts, or floats, and admission to the benefits of navigation on such canals as may be found most suitable to the peculiar circumstances of each. The rules thus drawn out shall be published for general information in the Government *Gazette*.

"III. And it is hereby enacted, that any acts done by private individuals in contravention of the rules so published, shall be punishable either by temporary depriva-

tion of the benefits of the canal, or by the penalties herein-after described.

"IV. And it is hereby enacted, that all balances of water-rent due for lands irrigated by the canal shall be levied, either by temporary deprivation of the benefits of the canal, or by the same process as is prescribed for the recovery of balances of land-revenue.

"V. And it is hereby enacted, that whoever wilfully causes any obstruction to any of the said canals, or to any of the water-courses drawn and supplied therefrom, or damages the banks of the canal, or the works constructed for its maintenance, or wilfully defiles the water in the canal, shall be liable to the penalties herein-after described.

"VI. And it is hereby enacted, that all persons offending against the provisions of this act shall be punishable, on conviction before the magistrate, by imprisonment without labour for a term not exceeding fourteen days, or fine to an amount not exceeding fifty rupees (about £5), or both; and, in default of payment of such fine, by additional imprisonment for fourteen days.

"VII. And it is hereby enacted, that if the owner of any boat, float, or raft, navigating any such canal, shall refuse to pay the prescribed toll, it shall be lawful for the officer charged with the levy of tolls on the canal to detain such boat, raft, or float; and if the toll be not paid in the course of ten days, then it shall be lawful for the said officer, under the direction of the superintendent of the canal, on the tenth day after the seizure, to sell such property, or so much thereof as may be necessary, or to declare the whole confiscated; provided that in all such cases no confiscation shall be carried into effect till the circumstances have been reported to the commissioner of the division, and his sanction obtained thereto.

"VIII. And it is hereby enacted, that it shall be lawful for the lieutenant-governor of the north-western provinces to appoint officers for the collection of the rents, tolls, and dues herein-before mentioned, and to confer on such officers the powers of deputy-collectors for the levy of such rents, and of joint magistrates for the enforcement of such penalties as have been herein-before specified."

The lieutenant-governor of the north-western provinces exercised without loss of time the powers vested in him by the preceding act, and the following resolution, which completes the details of our existing legislation, was published in the Government *Gazette* of the 1st of July 1845 :

"REVENUE DEPARTMENT,
the 31st of May 1845.

"RESOLUTION for giving effect to Act VII. of 1845 regarding Canals, passed by the Honourable the Lieutenant-Governor N. W. P.

"I. Under the powers vested in the Lieutenant-Governor N. W. P., by Section I. Act VII. of 1845, the provisions of the act in question are declared applicable to the following canals and water-courses :—

1st, The Western Jumna Canal, running through Delhi, and throwing off branches to Hissar and Rohtuck.

2d, The Eastern Jumna Canal, running near Saharanpoor.

3d. The Beejapoor Canal, in the Deyrah Dhoon, drawn from the left bank of the Tonse River, near the village of Beejapoor.

4th, The Rajpoor Canal, in the Deyrah Dhoon, drawn from the right bank of the Ruspunnah River, below the village of Rajpoor.

5th, The Nugeenah Canal, in the district of Bijnore in Rohilkund, drawn from the right bank of the river Koh, and passing by the town of Nugeenah.

"II. In conformity with Section VIII. of the aforesaid act, the superintendents of the said canals are invested with the powers of deputy-collectors for the levy of rents, and of joint magistrates for the enforcement of penalties under the aforesaid act; and their assistants are declared competent to exercise the same powers, under their directions, and on their responsibility. The subordinate establishments of such superintendents have the power of subordinate revenue and police officers for the aforesaid purposes. An appeal lies direct to the commissioner of the division against orders passed by the superintendent or his assistants in the capacity of deputy-collector, and to the sessions judge, against orders passed in the capacity of joint magistrate.

"III. The officers at present holding the above appointments, and vested with the above powers, are:—

WESTERN JUMNA CANAL.

Captain A. H. E. BOILEAU, Engineers, Superintendent.
Lieutenant HENRY YULE, do. } Assistants.
Lieutenant F. WHITING, do. }
Conductor W. DAWE.

EASTERN JUMNA CANAL.

Lieutenant R. BAIRD SMITH, Engineers, Superintendent.
Lieutenant W. E. MORTON, do. Assistant.

BEEJAPOOR AND RAJPOOR CANALS.

Captain HENRY KIRKE, Superintendent.

NUGEENAH CANAL.

The Collector, Deputy-Collector, and Assistant-Collector of Bijnore, for the time being.

"IV. In conformity with Section II. of the aforesaid

act, the following rules are passed, to be in force on the above canals and water-courses:—

"*Rules for the Western and Eastern Jumna Canals.*

"V. 1st, Cultivators whose lands lie within reach of the canal may, on their application, have water for irrigation at the following rates:—

DESCRIPTION OF PRODUCE.	Land irrigated by natural flow of water per acre.		Land irrigated artificially per acre.		For what period.
	In local currency.	In English currency.	In local currency.	In English currency.	
	Rupees.	L. s. d.	Rupees.	L. s. d.	
FIRST CLASS.—Fruit, or nursery gardens, . .	5 0 0	0 10 0	4 0 0	0 8 0	per annum.
SECOND CLASS. — Vegetable gardens, indigo, sugar-cane, tobacco, cultivated grasses — as lucerne, guinea grass, and herbs, . . .	2 0 0	0 4 0	1 8 0	0 3 0	per annum or crop.
THIRD CLASS. — Rice, cotton, wheat, oats, Indian corn, vegetables, (single crops,) and safflower, . . .	1 0 0	0 2 0	0 10 8	0 1 4	per crop.
FOURTH CLASS. — Barley, oil-seeds, pulse of all kinds, . . .	0 10 8	0 1 4	0 8 0	0 1 0	per crop.

"VI. 2d, When it may be more expedient to give water on contract rather than according to the surface irrigated, the terms of contract may be as follows:—

"Where the water flows naturally, 2 rupees (4 shillings) per annum for every square inch of opening taken from the summit-level of the water, and having a free course.

"Where the water requires to be raised artificially, the rate to vary according to the opening as above, or according to the machine used."

(Five forms of native machines for raising water are specified, and rates per annum and per crop fixed for each. These rates vary, according to the supposed working powers of the machines, from £3 to 12s. per annum on each, and between half of these extremes respectively per crop.)

"VII. 3d, In the event of any persons secretly taking water from the canal in any manner, for which rent is leviable, without coming under engagements to pay the rent, or secretly taking more water than he has engaged to pay for, he shall be chargeable with double rates for all water so taken.

"VIII. 4th, All land brought into cultivation within 20 yards of the canal or any branch stream from it, subsequently to the construction of the channel, shall pay water-rent, whether taking water or not; and similarly all land cultivated from wells which have been dug or re-opened within 20 yards of the canal boundary, or within 10 yards of any branch stream from it, subsequently to the construction of the canal, shall pay water-rent, whether taking water from the canal or not.

"IX. 5th, When, from the carelessness of cultivators, either in not properly closing the heads of their water-courses, or in leaving the water-courses in bad order, the water overflows and spreads over waste or fallow land, a fine shall be levied not exceeding the highest rate of water-rent leviable on the extent of land flooded.

"X. 6th, It shall be in the power of the canal officers to close the whole of the branch water-courses from sunset to sunrise, for the purpose of forcing the water on to the lower parts of the canal, and also, when necessary, for any period not exceeding three days in a week. At other times the water shall be at the command of the cultivators, provided it be in the power of the canal officer to furnish

a supply. Persons taking water once, so as to benefit a crop, shall be liable to the charge for the whole year, or the whole crop, as the rate may be leviable.

"XI. 7th, Special agreements between individuals and the superintendent for the use of water for irrigation, for driving machinery, or for other purposes, on other terms than are embodied in these rules, shall be construed as other ordinary contracts are.

"XII. 8th, When a branch water-course may have been formed by the owners of two or more villages at their joint expense, and the owners of any one of the villages, by refusing or neglecting to clear out their portion of the water-course, shall impede the free flow of the water, the superintendent shall be competent to cause the channel to be cleared at the public expense, and shall recover such sums as *tuccavee* (a local term, meaning advances in money made by Government to cultivators to facilitate agricultural or other like operations, and recoverable at times and in ways specially agreed upon) from the owners of the adjacent village, or of the villages profiting thereby, in such proportions as he may consider just, and according to the method prescribed in these rules.

"XIII. 9th, The superintendents and their assistants, in realising balances of advances and of water-rent, are empowered to proceed themselves against the persons or personal property of defaulters, under the provisions of the regulations applicable to the case; but if they consider it necessary to proceed against the real property of the defaulters, they will address a requisition to that effect to the collector of the district in which such property is situated. The collector, on receiving the requisition, will proceed in the same way as he would upon any similar requisition addressed to him by the collector of another district.

"XIV. 10th, Villages that pay less than 100 rupees (about £10) in the year for water-rent, or that do not take water upon contract, shall also be liable to the following charges:—

"For the watering of camels or cattle, 60 rupees (£6) per annum for every 1000. For the watering of sheep and goats, 20 rupees (£2) for every 1000.

"For filling tanks or reservoirs whenever water can be spared, 5 rupees (10s.) per 24 hours' run, for every 100 square inches of opening through which the water is supplied.

"XV. 11th, Villages that pay 100 rupees (£10) per annum shall be exempt from these charges, and those that take water by contract shall use the water so supplied to them in any way they prefer, but shall not be allowed to sublet it either for irrigation or for watering the cattle of other villages.

"XVI. 12th, Tolls at the following rates shall be levied on all rafts passing along the canal."

(Here follows a long list of rates for various species of woods and grasses, which I need not extract.)

XVII. to XX. Detailed regulations regarding the passage of rafts, and provisions for protecting the works from injury by them. The owners are made liable for the cost of repairs of such damages, and if they are caused wilfully or wantonly, the offender is rendered farther liable to punishment under Section V. of the act.

"XXI. 17th, Ferry boats shall not ply on the canal, except under license from the superintendent, to be given or withheld at his discretion; but no charge shall be made for such licenses. Any other boats kept on the canal, for purposes of pleasure or traffic, shall be licensed on such terms as may be agreed upon between the superintendent and the owners of the boats.

"XXII. 18th, The jurisdiction of the superintendents and their assistants as joint magistrates, in all cases provided for in this act, shall extend over all places within canal bounds, or, where there may be no apparent and recognised bounds, for 30 yards on each side of the high water-mark on any principal channel of the canal, and for 10 yards on each side of every *rajbuha* or other branch water-course, supplying water to more than one village, and over every plantation, building, or enclosure, belonging to the Government, and under charge of the canal officers. Beyond these limits they will have concurrent jurisdiction with the magistrate for the pursuit and apprehension of offenders.

"XXIII. 19th, Persons injuring the canal banks or the canal property within the aforesaid limits, or wilfully driving their cattle so as to damage the banks or the property, or otherwise acting within the said limits as prohibited in Section V. of the act, shall be liable to the penalties prescribed in the act; but for cattle accidentally straying, the penalty shall not exceed, for every elephant, 1 rupee, or 2s.; every camel, 4 annas, or 6d.; every buffalo, or head of cattle, horse, mule, pony, or ass, 2 annas, or 3d.; for every sheep or goat, 1 anna, or 1½d.; together with the expenses of feed and keep, and the cost of repair for damage done. Unclaimed cattle will be sent to the established canal pounds to be disposed of by the superintendent as usual, and the net proceeds of the sale will be credited to the canal. Cattle or other animals going down to the stream, or crossing it at any other places than the established *ghats* or fords, will be held to have been wilfully driven, or to have accidentally strayed, as the case may be.

"*Rules for the Beejapoor and Rajapoor Canals.*

"XXIV. 1st, Cultivators whose lands lie within reach of the canal, or of reservoirs filled from the canal, may, on their application, have water for irrigation from the canal, or the tanks or reservoirs made or repaired by the Government, and filled from the canal at the following rates :—

DESCRIPTION OF PRODUCE.	On land irrigated by natural flow of water per acre.		For what period.
	In local currency.	In English currency.	
	Rs. As. P.	L. S. D.	
First Class.—Fruit or nursery gardens, . .	2 8 0	0 5 0	
Second Class. — Vegetable gardens, indigo, sugar-cane, tobacco, cultivated grasses — as lucerne, guinea grass, &c., herbs and rice grown in enclosed beds, ...	1 0 0	0 2 0	per annum.
Third Class. — Rice not grown in enclosed beds, cotton, wheat, oats, Indian corn, vegetables (single crops), safflower, . . .	0 8 0	0 1 0	per annum. or crop.
Fourth Class. — Barley, oil-seeds, and pulse of all kinds, ...	0 8 0	0 1 0	

XXV. 2d, Repeats Art. VII., Rule 3d, of the foregoing series. When rules are exactly the same for different canals, I will not give them again in full, but merely refer as above to the corresponding provisions in the First Series.

XXVI. 3d, Repeats Art. IX., Rule 5th, of the First Series.

XXVII. 4th, Repeats Art. X., Rule 6th, of the First Series.

XXVIII. 5th, Repeats Art. XI., Rule 7th, of the First Series.

XXIX. 6th, Repeats Art. XII., Rule 8th, of the First Series.

XXX. 7th, Repeats Art. XIII., Rule 9th, of the First Series.

XXXI. 8th, Repeats Art. XXII., Rule 18th, of the First Series, with the following modifications:—The extent of jurisdiction is limited to 12 yards on each side of the main canal and principal branches, and includes not only the tanks and reservoirs as well as the canals, but also the course of the stream from which the canal is drawn, from the head of the canal to the debouche of the stream from the hills, or any place where water-courses may be cut or machines constructed.

XXXII. 9th, Repeats Art. XXIII., Rule 19th, of the First Series.

"*Rules for the Nugeenah Canal.*

"XXXIII. 1st, Cultivators whose lands lie within reach of the canal may, on application received within the prescribed dates, have water on the following terms:—

DESCRIPTION OF PRODUCE.	On land irrigated naturally per acre.		On land irrigated artificially per acre.		For what period.
	In local currency.	In English currency.	In local currency.	In English currency.	
	Rs. A^s. P.	L. S. D.	Rs. A^s. P.	L. S. D.	
FIRST CLASS.—Fruit and nursery gardens, . .	5 0 0	0 10 0	4 0 0	0 8 0	per annum.
SECOND CLASS.—Vegetable gardens, indigo, sugar-cane, tobacco, cultivated grasses, herbs,	2 0 0	0 4 0	1 8 0	0 3 0	per crop.
THIRD CLASS.—Rice, cotton, wheat, oats, barley, and all other kinds of grain and pulses, . .	1 0 0	0 2 0	0 10 8	0 1 4	per crop.

"XXXIV. 2d, Owing to the limited supply of water in the canal, it is necessary to fix the number of waterings which can be given to each crop. If there be not enough

water to give the prescribed number of waterings, a rateable deduction shall be made for the deficiency.

Description of Produce.	Number of Waterings.
Fruit or nursery gardens, . .	8 waterings per annum.
Hemp, ...	5 do. per crop.
Rice, sugar-cane, indigo, tobacco, cultivated grasses and herbs, .	4 do. do.
Cotton, wheat, barley, and all other grains and pulses, . . .	3 do. do.

" XXXV. 3d, The following dates are fixed, up to which applications will be received and registered for the different kinds of produce :—

For gardens, sugar-cane, tobacco, and extra-ordinary crops, ...	15th March.
For indigo, and the ordinary rain and winter crops, ...	1st June.
For vegetables, cultivated grasses, and the ordinary spring and summer crops, .	1st Nov.

" XXXVI. 4th, All applications tendered after the above-mentioned dates, to be treated at the discretion of the canal-officer.

1st, By absolute rejection.

2d, By granting the prescribed waterings, and charging double rates.

3d, By granting only one or two waterings, and levying the full rates.

" XXXVII. 5th, In the event of the cultivator being found to have irrigated more land than he had applied for, he shall be charged double rates for all the excess; provided, however, that no charge shall be made for any excess under 5 per cent on the area applied for.

" XXXVIII. 6th, If the excess prove uncultivated or fallow land, the rate levied shall be the highest rate of water-rent."

XXXIX. 7th, Repeats Art. VIII., Rule 4th, of the First Series, with the substitution of a distance of 10 instead of 20 yards from the canal and its main branches.

XL. 8th, Repeats Art. IX., Rule 5th, of the First Series.

" XLI. 9th, The canal officer shall be at liberty to close the canal once every year, for clearing the bed and repairing the banks; provided, however, that the period occupied in repairs shall not exceed one month, and shall always be chosen when there is the least demand for water."

XLII. 10th, Repeats Art. XI., Rule 7th, of the First Series.

XLIII. 11th, Repeats Art. XII., Rule 8th, of the First Series.

XLIV. 12th, Repeats Art. XIII., Rule 9th of the First Series.

XLV. Repeats Art. XIV., Rule 10th, of the First Series, substituting, as the charge for watering sheep or goats, Rs. 26 (£2, 12s.) for Rs. 20 (£2).

XLVI. Repeats the provisions regarding the filling of tanks or reservoirs given in Art. XIV., Rule 10th, of the First Series, substituting 20 for 100 square inches of opening.

XLVII. Repeats Art. XXII., Rule 18th, of the First Series, substituting 15 for 30 yards on each side of the canal as the limits of magisterial jurisdiction.

XLVIII. Repeats Art. XXIII., Rule 19th, of the First Series.

The act and resolution now given form the code of

irrigation in Northern India. They concern themselves, as it will at once be observed, simply and exclusively, with those relations which connect the government as the great proprietor of the canal waters, with the agricultural community as the employers of these. They are mute on all points which naturally arise between the different members of the latter body, whether these be village communities or individuals, during the development of a great system of irrigation.

Most of those judicious, effective, and considerate provisions, which regulate the interior circulation of the water of irrigation in the irrigated regions of Northern Italy, and especially in Piedmont, have still to receive the consideration, and I hope the ultimate sanction, of our local legislators. Perhaps the following brief summary of the points already established by the preceding enactments may not be without its use in facilitating a comparison of the systems of legislation in the Italian and Indian provinces.

On analysing the act and resolution, it is found that they are devoted to matters either of administration or police. Under the former head, the following are the principal points that have been determined :—

1st, The right of cultivators to water from the canals on demand, limited in all cases by the position of their lands, the adequacy of the supply, and in one instance by prescribed periods of time.

2d, The adjustment of the price of water on the basis of *special service* under the two distinct conditions of natural and artificial flow, or of *volume*.

3d, The regulation of the method of distribution and measurement on the basis of *work done* (whether in irrigation, or for machinery, or other objects), and on the *area* of the outlet of discharge.

In the former case, the water is issued from outlets altogether unregulated; the quantity is determined solely by the necessities of the cultivator; there are no inducements to economy of water; there are numerous facilities for fraud; there are incessant and harassing interferences with the irrigating proprietors; there are obstacles thrown in the way of the extension of the more valuable crops; there are uncertainties introduced into the system of agricultural operations, from the strong temptations to avoid using the water unless it becomes absolutely necessary. After ten years' observation of the practical working of the plan of issuing water from unregulated outlets, on the basis of special service, or area irrigated, I have come to the conclusion that it is the most unsatisfactory of all methods, whether reference be had to the true interests of the State, or those of the agricultural community. Its maintenance is justifiable only when physical circumstances offer insuperable obstacles to the use of any other plan.

In the case of measurement and distribution by volume, as defined in the enactments under review, there are serious imperfections. The terms in which Art VI., Rule 2d, of the First Series of Regulations is expressed, are, I am bound to say, extremely difficult, if not impossible, to understand. Where water flows naturally, a certain rate is leviable, "for every square inch of opening taken from the summit level of the water, and having a free course." I think if it were attempted to execute an actual measurement of an outlet of irrigation with this rule as a guide, failure would be inevitable. The height, the breadth, and the head of pressure of any outlet, are the *fundamental* conditions on which its discharge is dependent. The maintenance of these, as nearly constant as circumstances will permit, is the essential object of all

the definitions and rules, and forms of apparatus, which have been hitherto devised for measurement of water in irrigation. But the rule above given leaves all of these elements in extreme obscurity; and I confess I cannot obtain a clear idea of the conditions of measurement it is designed to establish. That in a matter of so much importance, such obscurity will be allowed to continue, is by no means likely; and I am sure attention has only to be drawn to its existence, to insure its being removed by the use of terms more definite and exact.

The above remarks apply equally to the case of water obtained by artificial means, since the area of outlet is retained as a principal element of the measurement of volume, and its value is of course equally difficult to ascertain.

4th, The establishment of protective distances. These vary from a maximum of 20 to a minimum of 10 yards, and their operation is limited to the Government canals and their main branches. In Art. VIII., Rule 4th, of the First, and Art. XXXIX., Rule 7th, of the Third Series of Regulations, there is an obscurity, to which I may advert for a moment. The measurement of the protective distances is directed to be made "from the canal." But a canal is not a mathematical line, having length without breadth; and the question at once arises as to what part of the canal is implied in the rule. Is it from the centre, or the edge of the channel nearest the lands benefiting by the filtration of the water, that the measurements are to be made? I conclude it is the latter line that is meant; but the terms employed in the rules leave it open to question. Again, in the case of irrigation from wells within the protective distances, the measurements are to be made "from the canal boundary." But this boundary is an extremely indefinite one. It is at very variable dis-

tances from the canal channel, and sometimes includes large areas of plantations and other grounds attached to the canal. If 20 yards is sufficient to protect the canal water, at points where the boundary approaches most closely to the canal, it is too much at others, where it recedes much farther from it, and the enforcement of the rule is an injustice to the cultivators in the vicinity of the latter localities. As protective distances have reference solely to the water in the canal channel, it is clear that they should be referred to the latter alone, and that the introduction of the canal boundary, as a new line of departure for the measurements, is not only useless, but mischievous. I make no comment on the distances themselves—they may, or may not, be effective for the purpose contemplated; details on this, or other like matters, are not at present under consideration; but the general principle of measuring such distances from some fixed point in the channel they are designed to protect, seems so much more clear, and at the same time so much more equitable, than the existing arrangement, that I have ventured to dwell a little upon it.

5th, The reservation of certain powers over the supplies of the canals to the government officers, to facilitate distribution of the water, and repairs of the works.

There is only a single instance in Art. XXXIV., Rule 2, of the Regulations for the small canal of Nugeenah, where provision is made for a failure of the supply. A rateable deduction from the water-rent is to be made for the deficiency. On the great canals there are no arrangements whatever for a contingency of this kind, and their absence is unquestionably a serious defect. The reservation of powers over the supplies made in Art. X., Rule 6, of the First Series of Regulations, is accompanied by the provision, that parties using water once shall pay rent for the whole

crop. Now, it is by no means a rare contingency for the supplies of the great canals to become inadequate to the demand, after the first watering has been given to the land; yet on the area of this first watering the full rent is leviable, under the act, though it may have been found impossible to continue the irrigation of the whole surface throughout the season. It may be true, as it certainly is, that a representation of the circumstances of such cases would probably obtain a total or partial remission of the claims of the State; but there are often strong personal feelings and interests, which cause officers to hesitate in doing this justice to the community; and even if these did not exist, the fair adjustment of revenue claimed to service rendered seems to me to merit the consideration of the Government. The terms of this adjustment are matters for local decision; but the principle should, I think, be as distinctly recognised on the great as on the minor canals.

6th, The establishment of certain obligations on the employers of common water-courses.

Art. XII., Rule 8, of the First, Art. XXIX., Rule 6, of the Second, and Art. XLIII., Rule 11, of the Third Series of Regulations, are all to the same effect, and present the solitary instance in which measures have been taken to secure the free internal circulation of the water of irrigation. That relieving the channels of water-courses possessed in common by several proprietors, from impediments to the free flow of the water, is neither the only nor the most essential condition of effective circulation, scarcely needs to be stated, after our review of Italian experience; but that it should stand alone, as the representative, in the canal legislation of India, of all the provisions found necessary to the progress of irrigation in Lombardy and Piedmont, only shows how completely we are as yet on the very threshold, as it were, of the subject.

7th, Arrangements for the realisation of government dues for water-rent, tolls, &c., which call for no special comment.

8th, Provisions for the interpretation of agreements made in terms different to those embodied in the rules.

9th, Prohibition to lease-holders against sub-letting their supplies of water.

Such is a summary of the chief—indeed, I may say the whole, of the administrative details established by law for the canals of Northern India. On contrasting this system with that of Piedmont, as the most complete yet devised, the prominent defects in it are—

1st, The absence of all provisions for the right of passage, as applicable to public or private canals or water-courses.

2d, The want of a unit of measure for water, or any satisfactory measuring apparatus.

3d, The want of provisions against the waste of water, after its employer or proprietor has made use of it himself.

4th, The want of any provisions for local and interior drainage—for what may be called the drainage of irrigation, in contradistinction to the general drainage of the country.

5th, Vagueness in the definitions of protective distances.

6th, The want of provisions to meet the various cases in which a deficiency of supply has to be compensated for.

7th, The absence of efficient arrangements for granting temporary or permanent leases of water from the canals.

8th, The want of any provisions for the protection of employers of water holding leases from the Government, in their relations with each other.

There may be other points of difference which experience would make apparent; but if the code of irrigation in India were to provide efficiently, and in conformity

with local feelings and customs, for the various matters included in the preceding list, the results would prove, I am sure, of a very interesting and valuable character. I have before given the reasons for avoiding specific details in this place, as the selection of these must be the joint work of men familiar with the wants and wishes of the agricultural population in different irrigating districts. Without avoiding all reference to details when this seemed appropriate, my object has been to direct attention to the broad features of the question as clearly as I could; and having done this, I may now pass on to another subject.

As regards the police of irrigation in India, and the penalties by which it is enforced, I have only one general remark to make—it is, that all the regulations hitherto made in this matter concern solely and exclusively the interests of the Government. The interests of the irrigating community have as yet received very little attention indeed. Works, the property of the State, are adverted to in the act, but it is silent regarding works the property of individuals. Water secretly taken, or, in plainer words, stolen from the public canals, is subject only to a double rate—a price which will at all times be gladly paid for it when irrigation is required. Even this most inadequate protection is not afforded in terms to water possessed under permanent leases or long contracts, when it is virtually the property of the lessees or contractors. I believe that stealing water should be stamped as a felonious act, quite as much as stealing money; and, after long practical experience of the working of our police enactments, I am obliged to say, that I think the whole question should undergo a careful revision, as the system does not at present fulfil the ends required from it, in protecting efficiently either the works or the water for irrigation.

The provisions for navigation, &c., are mere matters of detail, and are therefore beyond the limits I have prescribed for myself.

Before concluding these final remarks, I have a few words to say on the proceedings of the government of India, in the matter of sanitary legislation. After exhibiting the unsafe foundations, and tracing the faltering progress, of this branch of legislation in Northern Italy, it is with hearty satisfaction that I proceed to show the sensible and thoroughly practical manner in which the British government has begun to deal with the question.

For several years before any decisive measures were taken, complaints of unhealthiness, attributed to canal irrigation, had reached the ears of the Government. These complaints, however, were supported by evidence of a very indecisive, and occasionally of a contradictory, character. It was, therefore, wisely held, that to proceed to action, on grounds thus unsatisfactory, could lead to no permanently useful results, and it was resolved to submit the subject to investigation, with all the care possible.

Accordingly, on the 16th September 1845, a general order of the commander-in-chief, acting under instructions from the Governor-general of India, appointed a committee, consisting of two officers of the Engineers, and a medical officer, with instructions to report "on the cause of the unhealthiness which has existed at Kurnaul and other portions of the country along the line of the Delhi canal. The committee will also report whether an injurious effect on the health of the people of the Doab (the country between the rivers Ganges and Jumna) is or is not likely to be produced by the contemplated Ganges Canal." The field of the committee's observation was subsequently extended, and made to include the whole irrigated region in the north-western provinces.

The actual investigations of the committee were conducted by Major W. E. Baker, of the Engineers, and Dr T. E. Dempster, of the Horse Artillery—two officers in whose professional qualifications and rigid impartiality the most implicit confidence was reposed by all who followed the progress of the inquiry. Having been myself the superintendent of one of the canal districts submitted to examination, I accompanied the committee, and watched with, of course, a perfectly friendly, but at the same time a somewhat jealous care, the methods of investigation pursued; and I must say that nothing could exceed the scrupulous anxiety to arrive at the truth which marked the whole of the committee's proceedings; and I receive the conclusions at which they have arrived as decisive on those special points to which they are applicable.

There is no use in my travelling over the whole ground examined by the committee in this place, my object being only to show the manner in which the basis of a system of sanitary regulation has been laid, and the general results arrived at.

"Our principal object," the committee remark in paragraph 5 of their report, "was to ascertain what relation subsisted between certain physical conditions of the different districts, and the liability of their inhabitants to miasmatic fevers. The former could be noted with some degree of certainty; but, in the absence of official medical statistics, and with frequent reason to doubt the accuracy of oral testimony, though collected by ourselves, we could not obtain even an approximation to a fair comparison of the past and present sanitary condition of the inhabitants of different localities. In this difficulty, it was suggested by our medical member, that the condition of the spleen in any number of individuals would be a fair test of the probable frequency and degree in which they had

suffered from malarious influences. Having satisfied ourselves of the propriety of this test, and finding it easy of application, we determined to adopt it, and have based on the results so obtained the most important of the conclusions at which we have arrived. In Appendices B and C will be found a memoir by Mr Dempster, stating the medical grounds for the employment of the test, and the method followed in applying it."

In discussing the applicability of the test, Mr Dempster states, "There is no fact more generally known, or unhesitatingly admitted, by medical men, than that disease of the spleen is one of the most frequent consequences of malarious fevers. To enumerate all the authorities on this point, would be to quote most of the respectable writers on these subjects; but that Government may appreciate the value of the test I depend on chiefly for the determination of the comparative intensity of malaria in different localities, it will be proper to cite a few passages from two recent and well-known works, by authors respectively of European and Indian experience." Quotations follow from the *Cyclopædia of Practical Medicine*, and *Twining's Diseases of Bengal*, showing that enlargement of the spleen is frequent wherever intermittent and remittent fevers prevail. The value of the test is duly limited —absolute certainty is by no means claimed for it. "I have no wish," Mr Dempster states, "to exaggerate the true and legitimate value of the spleen test; nor do I venture to assert that it will indicate the remote causes of *all fevers*, or even of all pure endemic diseases of this class. There may be different kinds of malaria, giving rise to fevers of different types, and having different complications and consequences; or common continued and typhoid fevers may become mixed up with, and modified by, fevers of local origin. All these are worthy subjects

of future inquiry. But from what I have lately witnessed, I am fully persuaded that it will be found a true and faithful comparative measure of *marsh malaria* in its extended sense; and with *that* alone have canals and canal irrigation any proper connection."

The value of a test, such as is here referred to, valid in a medical sense, and incapable of concealment or suppression, is great in a matter so open to personal influences, errors, and prejudices. Without it, the inquiries of the committee, based, as they must have been, on oral testimony, in which no credit could have been placed, would have ended "in vague and unsatisfactory conjectures, and without a single fact collected among the agricultural population on which they could depend."

In describing the method of applying the test, Mr Dempster says, "At each place twenty children and twenty adults were selected, our chief care being to take a *fair sample*, not of the sick, but of the 'going about' population of the town or village under inspection. The avowedly diseased were discouraged from coming forward; and when brought were rejected, unless there were not others sufficient to make up the required numbers. We took subjects from all castes; and whenever it was practicable, examined a certain number of the agricultural labourers found in the adjoining fields, before entering the village, where our numbers were completed from other classes."—"As the great object was to make use of an unequivocal, but easily applied test, no case was ever registered as 'spleen,' *unless I had so distinctly felt the enlarged organ, that it could not be confounded with any other disease.*"—"Precisely the same mode of examination was followed everywhere; so that everywhere it furnished a fair scale of comparison. One-half of the subjects selected for examination was, in all practicable cases, composed of

children under the age of puberty: 1st, Because I believed young persons to be more liable to enlargement of the spleen than adults; 2d, Because the disease, when present, is in them more easily and certainly detected. For both these reasons, I considered children to be the more delicate test of malaria. The results amply confirm this opinion."

Mr Dempster adopted five degrees of size, and marked them by different signs, the letter O signifying a distinctly marked case, M one decidedly larger than O, and the mean between the five varieties, L a large spleen extending to, or near to the navel, VL a very large one passing across the medial line, and S a small but perfectly marked case of the disease. "The soft enlargements," he says, "were seldom registered, even when they presented themselves. I was generally obliged to put them aside among the 'doubtful cases;' for although very confident as to the real nature of the disease, a mistake was still possible. But when I felt a solid tumour in the left side, distinctly ascertained its shape, consistence, and the direction of its edge, and hence knew that such could only be an enlarged spleen, in so registering it we recorded a *fact* (not a mere medical opinion), resting, of course, on the credibility of the witness."

These notices will, I believe, suffice to give a fair idea of the spirit in which, and the means by which, the question of the sanitary relations of the canals in Northern India was examined. To give an idea of the area embraced by the researches of the committee, and the basis of facts obtained as above described, on which their conclusions rest, I may mention that they travelled, during the course of their inquiries, about 1400 miles, visited more than 300 inhabited localities, and personally examined upwards of 12,000 individuals of all ages, and in districts both irrigated and unirrigated.

I may advert very briefly to the principal conclusions to which these elaborate researches have led. It has been proved beyond a doubt, 1st, That in considerable portions of the districts under the influence of existing canals, sickness has been largely developed. 2d, That this sickness is not attributable to the results of irrigation, but to the canal-works or the water-courses of private individuals having intercepted the natural drainage of the country, and having thus led to the formation of swampy tracts, diffusing malarious influence around them. 3d, That where the soil is light, and the irrigation carried on by means of main distribution-channels, all the advantages of canal irrigation may be secured without the presence of any of those evils to be found in localities differently constituted. 4th, That under the favourable conditions above referred to, it is possible to have even large areas appropriated to rice-culture, without evil effects on the health of the population. 5th, That, however, when irrigation is introduced in localities naturally malarious, the intensity of the morbific principles is increased. 6th, That irrigation, with free surface-drainage carried on during the cold season, may be regarded as quite innocuous. 7th, That when malarious influences are developed by canal irrigation, their effects are remarkably local, almost strictly so. Great cities and military cantonments would therefore be protected, according to the views of the committee, by zones of from at least three, to at most five, miles radius round them being kept free from irrigation. It is very curious and interesting to find that the elaborate details on which this conclusion is founded should thus have led to a result similar to that adopted by a kind of practical instinct in Northern Italy nearly three centuries ago, and that the actual limits of the protective zones, as defined in 1847, should be so very nearly the same as those esta-

blished in Lombardy about 1575. 8th, That, as regards the influence of the Great Ganges Canal on the health of the population of the districts through which it will pass, the conclusion, warranted by the results of the committee's investigation, is, that if attention to drainage be made an indispensable condition of participation in the benefits of irrigation, an improvement, rather than a deterioration of the general salubrity, may in many instances follow the introduction of canal irrigation. That even anticipating cases in which local and physical peculiarities may be irremediably opposed to effective drainage, there is reason to believe that a far less amount of contingent evil will arise than has been experienced on the canals of the Jumna, originally constructed as these were, without reference to many important points which have been especially kept in view in projecting the great canal from the Ganges. 9th, That the agricultural community has unequivocally decided that the benefits it derives, in increase of produce and certainty of returns, from the use of canal irrigation, far outbalance, in its estimation, the evils which have arisen from its employment in certain unfavourably-situated localities. The demand for canal irrigation is continual and progressive ; it will absorb, as fast as it is given, the entire supply of water placed at command ; all other forms of irrigation are immediately displaced by it, and if we were content to accept the decision of the mass of the population, the problem would receive a speedy solution. The committee *has*, in point of fact, accepted this decision, but has accompanied it by those limitations and safeguards which are indicated by the results of their minute and careful investigations ; and these will, I think, be certain to command the respect of the masses for whose special benefit they have been devised.

It may be worth while to show what these limitations

and safeguards are in the case of the canal of the Ganges, the only great work which has been constructed since sanitary considerations have received the attention they so fully merit.

"The committee would recommend as follows :—

"1st, That the Ganges canal be kept as much as possible within soil; *i. e.*, that its ordinary surface-level should be below that of the country.

"2d, That earth wanted to complete embankments be never obtained from excavations made outside the canal, except in such localities as will readily admit of drainage.

"3d, That the canal and its branches be taken as much as possible along the water-shed line of the country, so as not to interfere with drainage; and in all cases where such interference may be unavoidable, that the executive officers be instructed to provide otherwise for the drainage.

"4th, That masonry drains be constructed under all main water-courses or bridge-ramps, whenever these cross the drainage of the country.

"5th, That no private water-courses from the canal be allowed, but that irrigation be practised exclusively from main water-courses.

"6th, That irrigation be prohibited within five miles of a military station, and within one or two miles of large native towns.

"7th, That in clearing embankments, the grass, weeds, &c., be not suffered to rot on the ground, but that they be burned as soon as possible after they are cut.

"8th, That irrigation be altogether prohibited in localities which appear naturally to possess a malarious character.

"The committee are aware that the adoption of the measures above recommended would involve an expense not contemplated in the original estimates for the Ganges Canal."

Notwithstanding the intimation in the last paragraph, the Government at once gave its sanction to the measures suggested. Although I have not yet seen the revised estimates for the canal, I am informed that, owing to the modifications and extensions of the works, the probable cost is now calculated at nearly one and a half millions sterling. It is not only, however, in new projects that measures are being taken to combine the use of irrigation with due precautions for the health of the community. On those lines which we have received as legacies from our Mahommedan predecessors, the old errors of alignment and level, with the evils to which they have given origin, are being vigorously combated; and even already manifest improvements have been made, while still greater ones are either in actual progress, or under consideration. The path of research entered upon by the committee should be earnestly pursued; the relations of canal irrigation to health should be still more minutely and systematically investigated; and, without being over sanguine, I must say, I look forward to the time when we shall be able to say that, in the irrigated districts, agriculture has been stimulated, its products placed beyond the vicissitudes of season, its returns made sure and abundant, without either actual loss of life, or diminution of physical energy on the part of the population.

My duty is now finished. I have filled in, to the best of my ability, those outlines which I traced in the early pages of this Report. I am conscious of many imperfections, due, in some cases, to the novelty of the subject; in others, to the difficulty of obtaining perfectly satisfactory materials; and in others again, to the foreign stores whence information had to be gleaned. I have, however, done my best; and all fair allowances will, I am sure, be made for the shortcomings which may be detected.

The development of the irrigation system in India is, I hold, one of the most important of the duties attached to our position there. It is fortunately a duty, too, which is, in every point of view, its own reward. While it promotes the prosperity of the agricultural classes, it secures and increases the financial resources of the State. While it contributes powerfully to the increase of the material enjoyments of the community, it has proved itself, by wide experience, to be a moral agent, gifted with civilising influences, of a nature readily recognised, and willingly submitted to. Statistical details and magisterial experience show clearly that where irrigation, with its pleasant train of consequences, is introduced, crime diminishes, plenty and security prove the best policemen, lawless habits yield to their genial influences, and men who were the Ishmaelites of society fall, without force or constraint, into the ranks of the great army of industry.

The value of the means whereby the scanty pasture-land, or the waste itself, may be converted into fields capable of yielding any, or all, of the rich products of Indian agriculture, or by which the localities already yielding such products may have their capabilities increased, and their returns secured, scarcely admits of being over-estimated. So long as agriculture is left dependent on the vicissitudes of the seasons, those periodic famines, which devastate the richest portions of our territories, may be expected to recur. So long as masses of the population wander over great tracts in search of a precarious subsistence for themselves and the cattle on which they depend, there will be dark spots, marked by much suffering, and requiring the constant presence of repressive force; or, finally, so long as the staple sources of the revenue of the State are so specially influenced by ebbs and flows of agricultural prosperity, there must be

those losses and sacrifices, of which past experience presents so many examples. In solving successfully the social and fiscal problems involved in such considerations as these, and others of a like kind, which will naturally suggest themselves, there are doubtless many agencies, moral and intellectual as well as physical, to be employed. But I believe that those who have watched most closely the influence of irrigation on the habits and feelings of the people, will be best disposed to rank it high in the scale of the material agents of civilisation. If I have succeeded in suggesting some means calculated to stimulate its progress, or facilitate its application in those rich and interesting regions of Northern India, to which personal memories especially attach me, my work will have its best and most pleasant reward.

INDEX.

A

Abbot, Lieutenant S. A., i. 307.
—— Colonel F., i. 369, 392.
Abercrombie, Sir R., i. 7.
Absorption of water in meadow irrigation, ii. 84, 97. See *Loss.*
Abuses in the regulation of outlets, ii. 17.
Acquedotto, Diritto di, i. 41, 200. See *Passage, right of.*
Adda River, i. 37, 59, 64, 68, 164, 166—description of, 175, 200, 258, 263—canals from, 245, 279, 280, 283.
Addetta River, i. 173, 200, 246, 251.
Adige River, i. 61, 166, 184, 293.
Administration of Piedmontese canals, i. 119; ii. 307 *et seq.*, 311—ancient, 101—of Lombard canals (ancient), 205—present, 169 *et seq.*, 217.
Advances to cultivators for branch watercourses (India), i. 337; ii. 340—for wells and tanks, i. 408, 409, 414.
Affitto in denaro, i. 51.
—— *a mezzadria,* i. 53.
—— *a grano,* i. 54.
Agogna River, i. 89, 91—canals from, 141.
Agostano (second hay crop), ii. 78.
Ajmeer, commencement of improvement in, i. 426—Colonel Dixon's proceedings in, 427—soil of, 428.
Akbar, emperor, i. 307, 308.
Alaric II., canal of, i. 87.
Alberti, Leon Batt., quoted, i. 261.
Ale (in water-meadows), i. 25; ii. 76, 91.
Ali Murdan Khan, i. 309, 311.
Alienations of water, perpetual, ii. 259. See *Rent-free al.—Sale.*
Alps, i. 84, 163.
Alserio Lake, i. 164, 243; ii. 190.
Ambrosian Library, i. 260, 262; ii. 117.
Anecdote illustrating effect of private property in water, ii. 257.
Apennines, i. 84.
Aquatic plants, growth of, in canals, i. 224, 231, 240.
Aqueducts, i. 112, 113, 287, 310, 374.
Arbogna Torrent, canals from, i. 142.
Area of irrigation from a given flow of water, ratio of, i. 116, 124, 134, 137, 138, 139, 141, 142, 143, 146, 147, 148, 149, 226, 242, 255, 277, 293—general average, 298—in water-meadows, ii. 84, 85—average in India, ii. 61, 87—in Italian rice culture, ii. 213.
Area, proportion of irrigated, in Piedmont, i. 156, 157.
—— proportion of irrigated, in the Milanese, i. 281.
—— proportion of irrigated, in Lombardy, i. 295, 296.
—— proportion of irrigated, on Western Jumna Canal, i. 330.
—— proportion of irrigated, on Eastern Jumna canal, i. 349.
—— irrigated between Adda and Oglio, i. 287.
—— irrigated between Oglio and Adige, i. 294.
—— of culturable land in Ganges Canal districts, i. 378.
—— of irrigated land, water charged by, ii. 5, 165, 280.
—— of outlet, water charged by simple, ii. 6, 347-8.
Artificial raising of water prohibited, ii. 204—rates on, (India), 339.
Assessment of drainage expenses in Milan, ii. 241, 244—of canal expenditure, 174-6, 201.
Associations for hydraulic works, i. 146; ii. 128, 169, 178, 186, 193, 201, 210, 217, 219, 237.

Associative principle, value of the, ii. 193, 218.
Auckland, Lord, i. 368.
Aulic Council, ii. 129, 156, 169.

B

Baker, Major W. E., i. 315, 316, 355, 356, 364, 369, 370, 392; ii. 147, 355.
Barattieri's hydraulic architecture, ii. 9.
Bardello River, i. 174.
Battaglia, Canal della, i. 199.
Battente, or head-pressure, ii. 28, 38.
Battie, Mr, project of Nujufghur drainage, i. 364.
Bays (architect), i. 108.
Beds of water-courses, property in, ii. 133, 149, 268.
Benaco, or Lago di Garda, *q. v.*
Benasco escape, i. 205.
Beneficial effects of irrigation in Italy, i. 94, 147, 158, 298—in India, 319, 331, 353, 361, 368, 396, 397, 421, 425, 429, 430, 431; ii. 363.
Beno Gozadini, Podesta, murder of, i. 212.
Bereguardo Canal, i. 201, 229—works, 230—establishment, 231—navigation, and area irrigated, 232; ii. 140.
Berra, D., on *marcite*, i. 59; ii. 87, 90, 95, 231.
Bertola (engineer), i. 229.
Biangini on legislation of irrigation, ii. 283.
Bidone, Professor, i. 10.
Bigotti (engineer), i. 234.
Bijapúr Canal, i. 351; ii. 336, 337, 343.
Bijnore, ii. 337.
Bilancio, i. 52.
Biraga Canal, i. 33, 138; ii. 19, 259.
Black, C. C., Esq., i. 75.
Black-mail paid to the Mairs, i. 401.
Blane, Lieutenant, i. 313, 314.
Blight and insects, ii. 102.
Bocca di Pavia, i. 220.
Boileau, Captain A. H. E., ii. 337.
Bologna, i. 199.
Bormida River, i. 151 — canal from, 152.
Bra, Canal di, i. 151.
Brebio River, canal from, i. 152.
Brembo River, i. 178.
Brescia, i. 61, 180.
Briglia, ii. 29, 34.
Brioschi on *marcite*, ii. 96.
Brisach, Marshal, i. 105.
Brivio Lake, i. 175.
Bruna River, i. 75.
Brunacci, i. 235; ii. 8, 13, 36, 39, 54.
Brunasio Porcha, ii. 118.
Bruschetti, Guiseppe, histories of canals, i. 48, 161, 197, 198, 203, 209, 247, 267, 276; ii. 54, 193.
Buffalora, bridge of, i. 34.
Buffon, Nadault de, Treatise on Irrigation, i. 6; ii. 85, 257.
Bunding system on the Cuggur River, i. 354.
Busca Canal, i. 33, 100, 137; ii. 19, 259.
Busse River, i. 184.

C

Calculations of discharge, with given dimensions, ii. 37, 38.
Caldone River, i. 294.
Caliphs, irrigation works of the Spanish, i. 202.
Caluso, canal of, i. 10, 100—its history, 105 — volume, 110 — distribution of slope, 111—headworks and tunnels, 112 — bridges, aqueducts, and revetments, 113-14—cost of construction, 114—of maintenance, 116—discharge, and area irrigated, *ib.*—returns, direct and indirect, 117; ii. 65.
—— *oncia di*, i. 109; ii. 17.
Calvi, M., i. 43, 45.
Camel's neck, ii. 141.
Camonian Mountains, i. 166.
Campari (water-bailiffs), ii. 77, 90, 189, 191, 193, 215.
Campo Veronese, ii. 212.
Canabio Lake, i. 162.
Canals of irrigation in Southern France, i. 7—property in, 16, 33, 41 (see *P.*) —private, 33, 41, 42, 67, 133, 134, 136 (see *Prop.*) — histories of, by Bruschetti (see *B*) — extent of minor, in Lombardy, 41—not successful as speculations, 153—aggregate length of Piedmontese, 158 — aggregate length of Lombard, 158.
—— influence of, on springs, ii. 108—Moorish, ii. 221—extensive, declared works of public utility in Piedmont, ii. 277.
—— and railways, their mutual bearings, 392, 393, 394.
Canal Act of Akbar, i. 308—by the Governor-General of India, ii. 334.
Canals systematically noticed. [For incidental notices see also under the separate names.]
CANALS IN PIEDMONT. *From the Dora-Repaira*, (1.) Veneria Reale, 103; (2.) Royal Park, 103—*from the Stura*, (1.) Canal Fiano, 104; (2.) Veneria Reale, 104—*from the Orco*, (1.) Canal of Caluso, 105—*from the Dora-Baltea*,

(1.) Canal of Ivrea, 122; (2.) Canal of Cigliano, 127; (3.) Canal del Rotto, 129—*canals from the Malesina, &c.*, 131—*from the Chiusella, &c.*, and *from the Elvo, the Cervo, &c.*, 131—*canals from the Sesia*, (1.) Canal Gattinara, 134; (2.) Roggia Mora, 135; (3.) Roggia Busca, 137; (4.) Canal Rizzo Biraga, 138; (5.) Roggia Sartirana, 139—*canals from the Agogna*, 141—*from the Arbogna*, 142—*from the Terdoppio*, 143—*canals on the right bank of the Ticino*, (1.) Canal Langosco, 145; (2.) Canal Sforzesca, 147; its branches, Sforzesco and Merengone, 147; (3.) Canals Molinara, Castellana, and Magna, 148; spring-fed canals, 148—*canals on the right bank of the Po*, 150, viz., *from the Stura* (Southern), (1.) Canal of the Stura, and (2.) Canal di Bra, 151; (3.) Canal of Pertusata, 152; (4.) Canal of Soprano, 152—*canals from the Tanaro and its tributaries, Ellero, Pesio, and Brebio*, 152—*from the Bormida*, (1.) Canal of Charles Albert, 152—Minor canals in the upper valleys, 154, 158—general summary, 155-9.

CANALS IN LOMBARDY. *From the left bank of the Ticino*, (1.) Naviglio Grande, or Grand Canal of the Ticino, 203; (2.) Canal of Bereguardo, 229; (3.) Canal of Pavia, 233—*from the right bank of the Adda*, (1.) Canal Muzza, 245; (2.) Canal Martesana, i. 258—*from the left bank of the Adda*—tabular abstract, 283—*canals of the Brembo*, 283-4—*canals of the Serio*, 284-5—*canals of the Oglio, right bank*, (1.) Naviglio Civico, 286; (2.) Naviglio Pallavicino, 286; tabular abstract, 287—*canals of the Oglio, left bank*, (1.) Cavo Fusio, 289—tabular abstract, 290—*canals of the Mella*—tabular abstract, 291—*canals of the Clisio*, 291—tabular abstract, 292—*canals of the Mincio*, (1.) Fossa di Pozzolo, 292; (2.) minor channels, 293—general summary, 295.

CANALS IN INDIA (Appendix).

Canals in operation.—Western Jumna Canals, 306-311, 314-333—Eastern Jumna Canal, 311-313, 333-350—*Deyrah Valley canals*, (1.) Bijapúr water-course, 351; (2.) Rajpúr water-course, 351.

Canals projected but not commenced.—canal from the Cuggur River, 354—canal from the Sutlej, 356, 361—other projects, 361—projects for the Punjaub, 395.

Canals in progress.—From the Nujufghur Lake, 362—Kutta Putthur Canal, 365—Grand Ganges Canal, 367-395.

Cantalupi, A., Treatise on Agricultural Engineering, i. 56.

—— laws and regulations, ii. 200, 237.

Capital, necessity of, to the Italian irrigation system, and amount required to work an irrigated farm, ii. 113.

Cardinali's collection of hydraulic writers, i. 47.

Carli's Censimento di Milano, i. 50.

Castellana Canal, i. 148.

Castiglione, Lake of, i. 72, 74.

Cattaneo, Carlo, his publications, i. 57, 161, 297.

Cattle of the Milanese, numerous, i. 38, 187.

—— revenue from watering, i. 321, 342; ii. 341, 346.

—— pasturing on canal banks, fines on, ii. 310, 342.

Cautley, Lieutenant-Colonel P. T., i. 334, 364, 365, 367, 368, 369, 370, 387, 392.

Cavi Sorgivi (spring-fed canals), i. 148.

Cavo Lerino Marocco, i. 42—Taverna, 67.

Cavour, Count de, i. 15; ii. 257.

Censimento (or revenue survey), i. 49, 50.

Cerio, or Cervo River, i. 89—canal from, 131.

Certosa of Pavia (monast.), i. 206, 260.

Challenge, singular engineer, i. 214.

Charles Albert's Code, i. 11, 12, 29, 110, 155; ii. 7, 67, 129, 130, 253, 256, 263, 285, 296.

—— canal, i. 100, 152.

Charles Emmanuel I., i. 106, 152; ii. 321.

———— III., i. 14, 107, 108; ii. 125, 126, 129, 270.

Charles V., emperor, ii. 124.

Cherio River, i. 166, 180—irrigation from, 286.

Chiana, Val di, i. 72.

Chianogna River, i. 154.

Chiaravalle, Cistercian monastery of, i. 199, 203, 260, 262; ii. 178.

Chiese River (or Clisio), i. 61, 166, 180, 181—canals from, 291, 292.

Chiesella R., i. 89—canal from, 131.

Chisone River, i. 154.

Chitang River, i. 307.

Cholmondeley, Mr, i. 75.

Choya River, i. 355.

Cicero, i. 75.

Cielo morto, ii. 50, 53.

Cigliano, canal of, i. 15, 16, 18, 100, 127.

Cisalpine republic, legislation of the, ii. 128, 144, 169, 178, 179.

Civil code, Lombardo-Venetian, ii. 129, 130, 131, 150—Sardinian. See *Charles Albert.*

Clearance canal, i. 224, 240, 252, 275; ii. 201, 211.

Climate, contrasts of, i. 7—of Turin, 9—of Piedmont, 92—of irrigated Lombardy, 188.
Clisio River. See *Chiese.*
Closing canals, mode of, i. 224, 252, 275; ii. 346.
Clusone, valley of, i. 165.
Coda dell' acqua (tail water), ii. 287, 288.
Colatori, colature (meadow drains and surplus water), ii. 78, 84, 90, 97, 158, 167.
Collyer, Dr, on sanitary state of Mairwara, i. 431-2.
Colmatage (warping), process of, i. 76—natural, 168; ii. 170, 266, 268.
Colombani's Practical Manual, i. 48.
—— hydrodynamics, ii. 39, 54, 77, 97.
Colvin, Colonel John, i. 314, 367, 392.
Committee of the Sardinian senate on rice cultivation, ii. 319.
—— See *Medical.*
Como, i. 65—Lake of, 164, 175, 263.
Company of the Canal Langosco, i. 146.
Comparisons between Indian and Italian fields of irrigation—the Muzza Canal compared with ancient Indian canals, i. 63, 256—the Naviglio Grande, 218—Canal works, economy of water and legislation, 69—as regards the two great fields of irrigation, 83—the cost of canal construction, 115, 153—returns on the outlay, 117—cost of distributing channels, 130, 339—as regards ratio of area lost to cultivation, 156—as regards the under current or percolation of river beds, 171—the torrents of the sub-Himmalaya, and those of the sub-Alpine regions, 175—as regards summer climate, 192—as regards land-tax on irrigated property, 255—the Muzza compared with the Western Jumna Canal in size, area of irrigation, works, and rental, 256—as regards ratio of irrigated to unirrigated area, 330—as regards winter irrigation, ii. 86.
Comparisons of population in irrigated and unirrigated Piedmont, i. 95, *et seq.*—of population in irrigated and unirrigated Lombardy, 193—of population and revenue in irrigated and unirrigated villages on Western Jumna Canal, 333—of population and revenue in irrigated and unirrigated villages on Eastern Jumna Canal, 348—of cost of canal and well irrigation, 383—of salubrity in irrigated and unirrigated districts, ii. 233.
Compost on *marcite*, ii. 95.
Conca fallata, i. 238.
Conditions of water-lease, ii. 140, 162, 282.
Consegna (or valuation survey), i. 51.
Conservancy of river channels, ii. 189.
Contini (engineer), i. 109; ii. 17.
Contracts for water-rent, i. 327, 337; ii. 338—for water supply, conditions of, 282.
—— for repairs, i. 253; ii. 177.
Contraction of the vein, ii. 15, 24, 38.
Convicted robbers, irrigation a medium of reclaiming, i. 412.
Corbolani (engineer) on Brescian measurement, ii. 33.
Corio, Signor, i. 22, 25.
Cost of canals—of Caluso, i. 114—of Canal di Bra, 151—of Charles Albert, 152-3—of Pertusata, 153—of Pavia, 241—Indian, 325, 345, 359, 365, 366; ii. 362.
Cost of maintenance of canals, 116, 127, 128, 151, 152, 153, 223, 241, 256, 278, 285.
Cost of rice irrigation, ii. 107. See *expense, expenditure, estimated,* &c.
Cremona, i. 59—canal of, 201.
Crescentino canal, ii. 15.
Crimes against property in water, ii. 316.
Cuggur River, 354.
Custodi, ii. 11.

D

Dairies of Northern Italy, ii. 94.
Dams—of Cigliano Canal, i. 16—of Ivrea Canal, 20, 123—of the Muzza Canal, 63—of the Martesana Canal, 64—Paladella on the Ticino, 220—of the Mincio, 293—temporary, 33, 224, 252; ii. 252.
—— at Dadoopoor, 315—at Fyzabad and Nyashur, 336—Nowgong and Kulsia, 337—Convex, 418.
—— spurs, and unauthorised obstructions, ii. 181, 189, 191, 199, 203, 208—unauthorised alterations of, 305.
Damages not claimable from the State by a water lessee, ii. 143, 144.
Damage to canal works, punishment of wanton, ii. 316, 341.
Danger of suffering regulation of irrigation to remain undefined, i. 215.
Danti, Ignazio, i. 75.
Dawe, Conductor W., ii. 337.
Debudé, Lieutenant, i. 331, 333.
Defaulters in water-rent, treatment of, (India), ii. 340.
Defects of present Indian canal legislation, ii. 347-353.
Deficient water supply, compensation for, ii. 143, 163, 291-2, 350-1—causes of, 292.
Delegations, provincial, ii. 175.
Dempster, Dr T. E., ii. 355-6-7.

Departures from normal *modulo magistrale*, ii. 53.
Deposits of silt, i. 18, 124, 316, 334, 336, 342, 354 ; ii. 63.
De Regi on outlets, &c., ii. 38, 54, 62, 83, 84.
Derivation of water, regulation of, ii. 144.
Deyrah Dhún (valley), i. 351, 365.
Dike of the Caluso Canal, i. 112.
Director of Canals (Piedmont), ii. 311.
——————(Lombardy), ii. 217.
Directors, Court of E. I. C., i. 3, 369.
Diritto d'insistenza (prescriptive right), ii. 138, 261.
Discharge, difficulties of the problem of, ii. 39.
Discrepancy in supply, recognised amount of, ii. 8, 284.
Dislike, mutual, between Piedmont and Lombardy, ii. 21.
Distribution of water—ancient, i. 101, 109—horary, ii. 66 (see *H*)—in Lombardy, ii. 160—in Piedmont, 280, 281.
Dixon, Lieutenant-Colonel, i. 306—abstract of his report on Mairwara, 397—his operations there, 403, 424, 425—in Ajmeer, 427, &c.
Donenini (engineer), ii. 31.
Dora-Baltea, i. 16, 20, 89, 91, 100—canals from, 122, 127, 129, 154, 157, 158.
Dora-Repaira River, i. 14, 91 — canals from, 103, 154, 157, 158.
Drainage—in Lower Lombardy, i. 60, 187, 294—of the Tuscan marshes, 74—of the Pontine marshes, 87—of city of Milan, 198—of the Deyrah valley, 361—of the Nujufghur lake, 362—sanitary importance of unimpeded, 432—interception of, 316, 337—system of Lake Maggiore, 161—of Lake of Como, 164—of the Ticino basin, 171—Olona and Lambro, 174—Adda and its tributaries, 177—Oglio, 180—Mella, 181—Clisio, 182—Mincio, 183.
—— combination of, with irrigation, ii. 235—of irrigation water, 77, 300—very necessary in India, 302, 352.
—— canals, regulation of, ii. 174.
Dredging machine, i. 275.
Dry cultivation in Piedmont, i. 157.
Durand, Major H. M., i. 363, 364.
Duration of water contracts in Lombardy, ii. 144.
Duties of canal officers (Piedmont), ii. 311.

E

Economy of a Piedmontese farm, i. 23.
—— false, i. 315, 316.
—— of canal irrigation, 383.
Ellero River, canal from, i. 152.
Elvo River, i. 89—canal from, 131.
Emanuel Philibert of Savoy, i. 105.
Embankments, river, i. 60—effect of high, 316, 336 — ancient tank near Delhi, 365—tank in Mairwara, see *Tank*—Solani, 374.
Emergencies, provision for (canal supply, &c.), ii. 306.
Emissardo on agricultural engineering, i. 56.
Emoluments of canal establishment in Piedmont, i. 121. See *Salaries*.
Endine Lake, i. 166, 286.
Engineers, education of hydraulic, in Piedmont, i. 12, 13—duties of, in Lombardy, 55—their number and skill, ii. 136, 159.
—— inspectors (Piedmont), their duties, ii. 311, 313—in Lombardy, 217.
Enlargement of channels regulated, ii. 266, 272.
Escapes attached to regulators, i. 18, 272—objection to using, as irrigators, 222. See *Outlets*.
Essentials of water measurement, ii. 56.
Establishment at canal-heads, i. 19—on Canal Caluso, 116—on Piedmontese government canals, 121, 127—on Naviglio Grande, 223—Bereguardo Canal, 231 — Pavia Canal, 240 — on Indian canals, i. 326, 347. See *Cost of Maintenance, Emoluments*.
Este, Beatrice d', i. 260.
Estimated cost per acre of Milanese irrigation system, i. 297-8.
Estimates (Piedmont), ii. 313.
Etruscan remains, i. 60, 71.
Eugene (Beauharnais), Viceroy, ii. 228.
—— Prince (of Savoy), ii. 325.
Example, force of, i. 426.
Expenditure on canals in north-western India, i. 352—on tanks in Mairwara, 430—on preparation of water-meadows, ii. 76.
—— assessment of canal, ii. 174-6, 201.
Expense of minor aqueducts, &c., how distributed, i. 239.
—— of forming *marcite*, ii. 76, 94—of irrigating *marcite*, 97—of Milan drainage canals, ii. 243.
Expenses and returns on land, irrigated and unirrigated, in Piedmont, ii. 80, 83—on *marcite*, 99. See *Cost*.

F

Falls, masonry, i. 22—on East Jumna Canal, 335—on Beejapúr Canal, 351—on Ganges Canal, 378.

Famine (Indian) of 1837-8, i. 319, 340, 368—of 1832, 408.
Fantone, Pio (engineer), i. 76.
Farm, interior of a Piedmontese, i. 23—rent and charges of a Milanese, ii. 83.
Farms, small, unsuited to the Italian irrigation system, ii. 113.
Farmer-proprietors of Lombardy, i. 55.
Farmers of canals (their powers), i. 122, 306.
Farming canals, evil of, ii. 258.
Ferishta (Indian historian), i. 313.
Feroze (Indian Emperor), i. 100, 306, 307, 308, 356.
Ferry-boats on canals (India), ii. 341.
Fevers, malarious, ii. 356. See *Malaria*.
Fiano, Canal of, i. 104.
Filiodone, Signor Danese, i. 210, 214, 267.
Financial pressure in Lombardy, evils of the, ii. 114.
Fines for breach of canal regulations, i. 106, 323, 344; ii. 167, 175, 180, 183, 184, 185, 186, 208, 242, 305, 308, 309, 310—(India), 335, 342. See *Penalties*.
—— for illegal cultivation, ii. 225-7.
Fishing, unlicensed, ii. 184, 189, 204, 308.
Flax-soaking prohibited, ii. 184, 192.
Floods, of Lake Maggiore, i. 163—of Lake Como, 165, 176—of Lake d'Iseo, 166, 184—of the Mincio, 184—of the Ticino, 204, 217, 218—of the Adda, 263.
Florence, i. 71, 80.
Flushing, process of, i. 275.
Fontanili (or irrigating springs), i. 33, 45, 61, 186, 292; ii. 90, 108 112. See *Springs*.
Forced sale of land, ii. 275.
Fords on canals (India), ii. 342.
Formula for value of Piedmontese water-measures, ii. 24.
—— for calculating claims under horary rotation, ii. 68.
Fossa interna of Milan, i. 259-260.
Fossils of the Sub-Himmalaya, i. 313.
Fossombroni, Count, i. 76.
Fountain-seeker, professional, ii. 108.
Fragmentary state of society in Italy, ii. 3.
France, author's route through, i. 6.
Francesco Sforza I., i. 201, 258.
Frederick Barbarossa, i. 198—I. (Emperor), ii. 118.
—— II. (Emperor), i. 200, 204.
French reports on Italian irrigation, i. 5, 6.
—— destroy the works of Naviglio Grande, 217—of Canal Martesana, i. 267.
Fusio, Cavo, i. 289.

G

Galeazzo Giovanni, Visconti, ii. 121.
Ganges Canal, i. 115, 172, 190, 257—history of the scheme, 367 *et seq.*—Medical Committee, 371—head-works, *ib.*—obstacles from sub-Himalaya drainage, 372-375—Solani Aqueduct 374,—branches, 375-376—total length, 376—expected benefits, 377—estimated irrigation, 378—and revenue, 379—value of crops secured by, 381—of increased production, 382—navigation, 384—objections to, 385—recommendations of Medical Committee regarding, i. 394—ii. 354, 361, 362.
Ganges River, expected effect of the canal on, i. 385, 387—tributaries of, 389.
Garda, Lago di, i. 61, 167, 182.
Gattellation, ii. 141.
Gattello, ii. 49, 53, 64, 141, 183.
Gattinara Canals, i. 100, 134.
Genoa, i. 7, 69, 95.
Gessa (seconda) River, i. 154.
Giovanetti on the law of irrigation, &c., i. 11; ii. 124, 131, 261, 269, 283, 299, 300, 331.
Goitre, story regarding, i. 312.
Goojurs, effect of irrigation facilities on the lawless, i. 398.
Grana River, i. 151.
Grandone River, i. 154.
Grandoni, Chevalier (engineer), i. 79.
Grantees of water, their selfish conduct, ii. 138.
Grants of water (Piedmontese), forms respecting, ii. 249.
Grassini, Mons., i. 61.
Greathed, Lieutenant W. W., i. 332.
Guardians of canals, i. 121, 223—qualifications, 274; ii. 190.
Guisani and Giudici (engineers), i. 235.
Guone, Canal of, i. 153.
Gurone River, i. 91.

H

Hall, Colonel, superintendent of Mairwara, i. 403—his exertions for the improvement of the people, 404, 408.
Head of pressure, constant, i. 209.
Henry II. of France, i. 105.
Himmalaya, i. 71, 311, 315, 336, 357, 366, 372, 385.
Hindun River, i. 369.
Historical summary of Piedmontese irrigation, i. 99.

Historical summary of Lombard irrigation, i. 196.
—— notices of Indian Canals, i. 306 *et seq.*
Holidays, right to water on, ii. 286-287.
Horary rotation, distribution by, ii. 66, 85, 162, 288—table, ii. 67—solution of problems arising in, 69.
Hydraulics, experimental, i. 14, 352.
Hydrography of Piedmont, i. 88 *et seq.*—of Lombardy, 160 *et seq.*
Hydrometers, i. 222, 240, 252, 273.
Hydrometric sluice, ii. 44, 46.
Hygrometric indications in Lombardy, i. 189.
Hutchinson, Lieutenant G., i. 365.

I

Idro, Lago d', i. 166, 181.
India, foreign impressions regarding English in, i. 257—irrigation in Northern, 306 *et seq.*—in Central, 397—in Southern, 305—importance of a system of irrigative legislation and distribution for, 215—existing irrigative legislation in, ii. 333.
Indian irrigation works, i. 3, 63, 69, 100, 115, 117, 153, 222, 256, 257; ii. 58, 279, 290, 293, 294, 295, 301, 332, 334, See also *India, Area, Ajmeer, Beneficial, Canals, Comparisons, Drainage, Legislation, Mairwara, Measurement, Passage, Tables, Unit,* &c. &c.
—— regulating sluices, 18—*jhâm* for well-sinking, 45.
Ingegneri Avvocati, i. 56.
Instructions to the author, i. 3.
Interchange of outlets, ii. 290—of rotation periods, *ib.*
Irrigation, works on Italian, i. 6 (see *Italian*)—from springs (see *Fontanili*), —ancient traces of, 86—beneficial effects of (see *B.*)—influence of, on population (see *P.*)—trifling effect of, on atmospheric moisture, 190—total extent of, in the Po Valley, 299—projected in the Punjab, 395; ii. 279. See also *India.*
—— practice of, in Northern Italy, ii. 3.
—— general organisation of, in Lombardy, ii. 217.
Iseo, Lago d', i. 165, 166, 179, 289.
Italian irrigation literature, i. 9, 10, 15, 40, 47, 48, 57, 58, 59, 161, &c.—general list of authors, Appendix *A.*, p. 301.
—— Scientific Congress, i. 58.
Ivrea, Canal of, i. 20, 100—history, 122; ii. 14—description and extent, 123—silt deposits, 124—discharge and area, irrigated, *ib.*—price of water, 125—branches, *ib.*—bridges, 126—revenue and maintenance, 127.

J

Jatonwala Torrent, i. 311, 336.
Jehan, Shah, i. 309, 311.
Jumna River, i. 307, 311, 366—effect of canals on, 385—under current in, 386—disputes regarding claims to water from, ii. 262.
—— Canals, i. 63, 115, 256; ii. 336—their history, 306-313. *Western Jumna Canals:* Development, 314—works, 317—water-rent, 318—benefit from, during famine valued, 319—mill rent, 320—watering cattle, 321—transit duties, *ib.*—plantations, 322—fines, 323—statement of expenditure and revenue, 325—establishment and superintendence, 326, 328—statement of population and revenue in canal districts, 329—increase of land revenue due to, 332. *Eastern Jumna Canal:* Evils of original levels, 334—Colonel Cautley's remedial measures, 334-336—difficulties, 336—assessment and distribution of water, *Rajbuha* system, 337—its cost and advantages, 339—canal works, *ib.*—water-rent and valued benefit in famine, 340—mill-rent, 341—watering cattle, 342—transit duties, *ib.*—plantations, 343—mango gardens, 344—fines, *ib.*—statement of expenditure and revenue, 345—establishment, 347—statement of population and revenue, 348—increase of land revenue due to, 350—legislation regarding, ii. 336 *et seq.*
Juntas, Spanish Irrigation, ii. 219.
Jurisdiction conferred on canal officers (India), ii. 337, 342, 346.

K

Keir, Dr, on sanitary state of Ajmeer, i. 432-433.
Kirke, Captain H., i. 351; ii. 337.
Kirsunni River, i. 312.
Kramer, Professor de, i. 42.
Krentzlin, Mons., i. 161.
Kutta Putthur Canal, i. 365.

L

Labour, cost of, in Italy, i. 114.
Lake system of Lombardy, i. 66, 160-161,

167—data regarding, 169—its beneficial agency, 176—awanting in Piedmont, 90—except on the Ticino, 145.
Lambro River (Northern), i. 164, 173, 198, 200, 205, 243, 246, 273; ii. 89, 90—Association of the, 186—administration of, 187, 190—(Southern), 172, 173, 205.
Land taken for canals, compensation for, i. 105, 258; ii. 119, 122, 123, 126, 148, 265, 271, 275.
—— rent, system of, in Lombardy, i. 51—effect of irrigation works on, in Piedmont, 158—in Milanese, 228—between Adda and Oglio, 288—between Oglio and Adige, 295—in Lombardy generally, 297.
—— revenue (India), increase to, from irrigation works, i. 332, 423, 429, 431.
—— assessment in Mairwara, 414—in Ajmeer, 429.
Landlord and tenant in Lombardy, i. 50.
Landolfo (historian), i. 198.
Langosco Canal, i. 33, 100, 145, 218—company of the, 146.
Laws of irrigation, earliest recorded, ii. 118.
Leases in Lombardy, i. 52—of canals, 120.
—— of water, perpetual, ii. 135, 161—temporary, 135, 139, 140, 144.
—— (India), i. 327, 352.
Lecchi, Count A., i. 62.
——, Antonio, work on canals, i. 161, 261.
Leghorn, i. 73.
Legislation of irrigation, i. 4, 6, 11, 69—sanitary, 26, 59—works on, 58, 59—superior in Lombardy, 187—necessity for, in India, 215—history of, in Italy, ii. 117—leading principles of, 120—traditional, 118, 121, 124, 125—in Lombardy, 131—in Piedmont, 248—in India, 333 *et seq.*—remarks on, 347—defects of, 352.
Lemma River, i. 154.
Leonardo da Vinci, his hydraulic writings and constructions, i. 40, 201, 262, 263.
Leri, visit to farm of, i. 22, 28.
Lettsom, Mr, i. 8.
Levels of Piedmontese canal beds, imperfect, i. 19.
—— normal of the *modulo magistrale*, ii. 52.
Limit of size of outlets, ii. 55, 56.
Liro River, i. 164.
Litigation regarding water, i. 133, 205, 246; ii. 148, 153, 257, 261, 270—impediments to, needless, 284.
Locks on canals of Milan, i. 39, 201, 259, 263—on the canal Bereguardo, 230—on Canal of Pavia, 238—invention of, 260-262—gigantic projected, 279.
Lodi, i. 42, 59.
Lombardini, Signor Elia, i. 60, 161, 172, 203, 260, 286; ii. 27, 112, 217.
Lombardy, hydraulic works of, i. 34—books on, 57—Lakes of, see *Lakes*—hydrography of, 160 *et seq.*—historical summary of irrigation in, 196—general summary of irrigation in, 295—superiority of irrigation system in, 187—state of, in the dark ages, 192. See also *Population*, &c.
Lonati, Bern. (engineer), i. 212.
——, Gian Batt. (do.), i. 213.
Loss of water, on *marcite*, i. 46—in canals, 225, 242, 254, 276.
Lucca, i. 79.
Ludovico Sforza, i. 32, 40, 135, 138, 147, 201, 260, 262; ii. 18.
Lugano, Lake, i. 162.
Lumberdars (India), ii. 219.
Lumellina (statistics of), 27, 94—expense and returns of agriculture in, ii. 79, 83.
Lungone River, i. 154.

M

Machines for raising water, rates on (India), ii. 339.
Macina of Modena and Reggio, ii. 9, 10.
Madras government, irrigation under, i. 305.
Maggengo (1st summer hay crop), ii. 78.
Magghengino (occasional 2d do.), ii. 78.
Maggi, Bishop B., i. 291.
Maggia River, i. 163.
Maggiore, Lago, i. 67, 145—hydrography of, 162-163, 263.
Magna Canal, i. 148.
Mairats, i. 400.
Mairs, i. 399 *et seq.*
Mairwara, irrigation in, i. 397 *et seq.*—character of the people, 399-400—conquest, 401—divided rule, 402—consolidation and results, 403—Hall's reforms, 404—Colonel Dixon appointed, 405—water the great want, *ib.*—his measures to provide it, 407—wastes reclaimed, 410—convicts reclaimed, 412—assessment, 414—tank embankments, 414-419, 420, 421—weirs, 419-420—other civilising measures, 424—general results, 425.
Malaria, i. 71-72; ii. 219, 332, 356, 359. See *Sanitary and Protective Zones*.
Malcorrente Canal, i. 285.
Malesina River, canal from, i. 131.
Manetti, Chevalier, i. 72.
Mantua, i. 60—lakes at, 182, 199—Regu-

lation of waters in, and Verona, ii. 198, 208.
Manure, abundance of, in Lombardy, i. 38, 187—application of, to irrigated meadows, ii. 89, 94, 95, 96 — on rice-lands, 105.
Marcite (or winter meadows), i. 24, 33, 46, 59, 61, 62, 93, 149, 197, 226, 228, 232, 255, 278, 288; ii. 86 *et seq.*—preparation of, in detail, 90-94 — produce of, 98—expenses and returns, rent, 99—sanitary relations of, 220, 231-232 — laws regarding, 140, 142. See *Meadow.*
Maremma, the, and remedial measures, i. 71-79.
Mari, experiments by, ii. 62.
Maria Theresa, ii. 128.
Marioni, Chevalier, i. 16; ii. 318.
Marocco, Cavo Lerino, i. 42, 43.
Marshes, i. 186, 197, 294.
Martesana Canal, i. 37, 39, 42, 64, 173, 201—history, 258—slope, 270—works, 272—establishment and repairs, 274—outlets, 275 — volume, 276 — area irrigated, and price of water, 277; ii. 140, 186-187, 189.
Mazzeri, M., i. 45—estimate of the *oncia*, ii. 54.
Meadows, summer, irrigation of, ii. 75—preparation, 76 — produce, 78 — returns, 79 — temporary, *ib.* — sanitary bearings of, 220, 231.
Meadows of the Po Valley, ii. 75—limitation of irrigated, 227-228, 231.
Measurement of water (in the Vercellese), i. 29—(in the Milanese), 39, 44, 109, 155, 202, 205, 206, 234, 248—ideas involved in, ii. 6—in Parma and Placentia, 9—in Modena and Reggio, *ib.*—in Ferrara and Romagna, 11—in Piedmont, 13—in Lombardy, 26—in the Venetian provinces, 36—legislation regarding, 160, 280—in India, its defective state, ii. 5—and apparatus for, discussed, 62. See *Modulo*, &c.
Measures, variety of, ii. 3—books on, 4, 26.
Meda, Giuseppe (engineer), i. 233, 279—gigantic lock projected by, 280.
Medical committee on effects of irrigation (India), i. 338, 370, 431; ii. 59—its appointment and proceedings, 355—conclusions and recommendations, 359.
Medici, Cosmo de', i. 74.
Mella River, i. 61, 180—canals of the, 291.
Mellea River, i. 151.
Menasciutto Canal, i. 285.
Mera River, i. 164.
Mercer, Mr G., i. 313.
Merengone Canal, i. 147.
Merlo's experiments on the *oncia*, ii. 54.
Mezzola Lake, i. 164.
Michela, M. (engineer), i. 10—history of Caluso Canal, 105, 124, 137.
Michelotti, Dominico (engineer), i. 10, 14; ii. 17.
——, Ignazio (engineer), i. 110—*oncia* of, 17.
Milan, i. 35, 68—canals in and round, 37, 172, 197, 259; ii. 236 (see *Naviglio Interno, Canal of Pavia, Martesana, Vettabia*, &c.)—statutes of, i. 200; ii. 117, work on, and its territory, i. 58; ii. 78, 104—drainage system of, 236—sewage, *ib.*
Military Board (Calcutta), injury to Major Durand's project by, i. 363.
Mills, i. 279 (Indian canal), 320, 341, 351, 352—regulations regarding (Italy), ii. 184, 188, 203, 208. See *Motive Power.*
Minago River, i. 184.
Mincio River, i. 166—description, 182, 199—canals from, 292.
Minor irrigation of the Milanese, i. 248.
Mir-áb, i. 308.
Missaglia, B. (engineer), i. 279.
Mission of the author to Italy, i. 3.
Models, necessity for machine, in India, i. 341.
Modulo, i. 44, 109, 155, 202, 208, 210, 255—of Piedmont, ii. 20, 282—*magistrale* of Milan, i. 39, 208, 242, 248—history, 209 *et seq.*—detailed description of, ii. 47, 54—objections to, 63, 41, 44, 140, 161, 162 — of Cremona, 56.
——, essential conditions of a trustworthy, ii. 39, 40, 46, 56.
Moggio Lake, i. 175.
Molgora Torrent, aqueduct across, i. 271.
Molinara Canal, i. 148.
Monçada, Spanish canal of, ii. 220.
Montferrat, Dukes of, i. 100, 105, 129.
Moors of Spain, ii. 221.
Mora Canal, i. 32, 100, 135; ii. 19, 259.
Mornay, Mauny de, report on irrigation, i. 6.
Morton, Lieutenant W. E., ii. 337.
Motive power from canals, &c., i. 147, 153, 174, 193, 228, 255. See *Mills.*
Moulan (rude French water-measure), ii. 10.
Muskurra River, i. 311, 336.
Muzza Canal, i. 59, 63, 173, 200, 234; ii. 26—history, i. 245—description, 250—slope, *ib.*—works, 251—repairs, 252—volume, 253—revenue, 254—area irrigated, 255—cost of maintenance, and

value of the waters, 256—compared with Indian canals, *ib.*
Muzza Canal, congregation of the, ii. 193—regulation of the, 194.

N

Napoleon, i. 37, 68, 202, 235; ii. 225.
—— Code, regarding property in rivers, ii. 131.
Narses, i. 408, 409, 427, 430.
Navigable rivers, property in, ii. 132.
Navigation of canals, i. 223, 262, 279.
—— and irrigation, combination of, i. 232, 236, 259, 266, 343, 370, 371, 373, 384, 393; ii. 11, 334.
—— dues, i. 266, 269, 321, 342; ii. 335, 341.
—— of Jumna and Ganges, to what extent affected by canal abstraction, i. 387-391.
Naviglio Grande of the Ticino, i. 34, 37, 39, 67, 173, 200, 235—history, 203 *et seq.*—description, 218—slope, 220—works, 220-223—establishment and repairs, 223—discharge, 224—waste of water, 225—supply in dry seasons, *ib.*—area irrigated, and outlets, 226—price of water, *ib.*—income, 228; ii. 27, 45, 127, 140, 146, 148.
—— Interno (of Milan), i. 37, 201, 243, 259, 271; ii. 88, 236.
—— di Paderno, i. 279—Vercellino, 263—Civico (of Cremona), 201, 286; ii. 31—Pallavicino, i. 202, 286; ii. 31—Taverna, 112. See *Canal*, &c.
Nerone River, i. 198.
Nice, i. 7.
Noé, M. Charles, i. 15, 16, 20, 22, 32, 90; ii. 111.
Nowgong Torrent and dam, i. 311.
Nugeena Canal (India),i i. 337, 344.
Nujufghur Lake (India), drainage of, i. 362—Major Durand's scheme, 363—Mr Battie's, 364.
Numerical details connected with irrigation in Northern Italy, ii. 107.
Nya-Nuggur, foundation of (in Mairwara), i. 424—fair established, 425.

O

Obstructions to water-courses, ii. 335. See *Dams*.
Occhi (spring-jets), ii. 110.
Office of canal works (Piedmont), i. 119.
Oggionno Lake, i. 164.
Oglio River, i. 61, 165, 166—description, 179, 182, 201,—canals from, 286, 289.
Oilcake, ii. 95.
Olginate Lake, i. 175.
Olona River (Northern), i. 172, 198, 243; ii. 45, 89—association of the, 128, 178, 179—regulations of the, 180.
—— (Southern), i. 173, 205.
Ombrone River, i. 75, 77.
Oncia (or water-inch), different meanings, ii. 14—of Caluso, i. 109; ii. 17, 24—of the Novarese, 18—of Lodi, 26—of Cremona, 27—of Crema, 31—of Bergamo, 32—*magistrale* of Milan, 47—various estimates of, 54—and causes of discrepancy, 55.
Opposition to canal reforms, i. 212, 213, 249.
Orco River, i. 88, 89, 91, 100, 154, 158—canals from, 105-117.
Organisation of hydraulic associations, ii. 170.
Orobian mountains, i. 166.
Orta, Lago d', i. 163.
Osa, Guglielmo dell', i. 199.
Osone River, i. 294.
Otho, emperor of Germany, ii. 117.
Outlets, escape, i. 63, 65, 77, 205, 222, 272, 293, 310, &c.
—— of distribution, i. 29, 44, 101, 109, 113, 206, 208, 223, 226, 231, 242, 254, 275; ii. 15—wooden, 32, 59—Piedmontese, 21—Cremonese, 28, 30—Brescian, 33—Milanese, 45, 48—regularisation of, 182—unregulated, 280, 285—removal of, from canal bank desirable, 63—Indian, 59—extraordinary tax on, i. 217, 268.

P

Paderno, canal of, i. 202.
Paladella dam, i. 220.
Pallavicino Canal. See *Naviglio*.
Parapets of canal-road embankments, i. 240.
Paratoja (sluice), ii. 22, 27, 31, 34, 43, 44, 49, 162.
Partitori, i. 113.
Passage, right of (for water-courses), i. 41, 200; ii. 119, 120, 122, 125, 126—in Lombardy, 146—law of, 151, 154, 157—in Piedmont, 263, 269, 278—limitations and conditions, 150, 264-267, 269—as existing in India, 147—as applicable in India, 279, 352.
—— through existing channels, ii. 127, 158, 270.
Pavia, canal of, i. 37, 68, 171, 201, 202—history, 233—distribution of slope, 237—works, 238—establishment and clearance, 240—maintenance, cost, and

revenue, 241—volume, *ib.*—area irrigated, 242.
Paving canal bottoms, i. 223, 241.
Payment for water, forms of, ii. 214.
Pellice River, i. 151, 154.
Penal legislation for Indian canals, ii. 318.
Penalty, heavy, for illegal irrigation, ii. 208, 211.
—— for breach of canal law, ii. 339, 341, 342, 353. See *Fines, Punishment.*
Percolation, facts regarding, i. 170—in the Jumna and Ganges, 386, 388—supply of wells by, 407—loss by, ii. 295.
Periods of irrigation, limited, ii. 345.
Periti, ii. 159, 207, 255.
Pertusata, canal of, i. 152, 153.
Peschiera, i. 61.
Pessina (engineer), i. 269.
Pessio River, canal from, i. 152.
Pezoretti on agricultural engineering, i. 56.
Philibert of Savoy, i. 101.
Piane. See *Ale.*
Piedmont, author's visit to, i. 7-34—hydrography, soil, climate, and population of, 88-98—historical summary of irrigation in, 99-102—canals of, 103-153—irrigation in upper valleys of, 154-155—general summary of irrigation in, 155-159—systems of measurement, ii. 13-26—expenses and returns on land in, 80-83—legislation of irrigation in, 248-332.
Piedmontese hydraulic literature scanty, i. 10.
—— farm, visit to a, i. 22—roads, 28.
Pietro Leopoldo, Duke, i. 74, 75.
Pigsties, economic value of, ii. 95.
Piste (rice-cleaning machines), i. 23.
Plana, Baron, i. 15.
Plantations along canals, i. 322-323, 343-344—ii. 310, 312—on irrigated lands, 99.
Plasticity of the Lombard irrigation system, i. 43.
Pliny, i. 74.
Plundering habits of the Mairs, i. 400.
Po River, i. 33, 37, 60, 68, 201, 205—obstacles to its use hitherto as a source of supply, 84, 90—projected canal from, 158.
Polenta (maize flour), i. 62.
Police espionage, i. 36.
—— of irrigation, Lombardy, ii. 169—Piedmont, 304—India, 353.
Ponale River, i. 167.
Poncelet and Lesbros, hydraulic experiments of, ii. 24, 39.
Ponte d'Archetto, i. 198.
Ponti, I. Tredici, i. 287.
Population of Piedmont, i. 94, 95—of Lombardy, 192—of Indian canal districts, 329, 348—bearing of irrigation on, 192-196, 329, 348, 422.
Possenti on agricultural engineering, i. 56.
Possession of water pending litigation, ii. 304.
Prati a vicenda (rotation meadows), ii. 79.
Prescriptive rights to water, ii. 260-261.
Price of water, i. 117, 125, 129, 135, 136, 137, 140, 141, 142, 143, 146, 147, 148, 151, 154, 226, 254, 277, 288—average in Lombardy, 298; ii. 213, 214, 216—for winter irrigation, 97—(India), 338, 343, 344.
Prisme, i. 19.
Private canals, administration of, ii. 315. See *Canals.*
Profiles, permanent, of canal section, i. 224, 231, 252; ii. 242.
Profits from canals, i. 42.
Progress of canal system in Piedmont, i. 101-102.
Property in water, i. 62—in canals, 106-107, 119, 122, 133, 134, 136, 146, 147, 199, 207, 245, 247—absolute in water for irrigation, ii. 135, 212, 213—private, in water, 254, 259—in running water, 131, 137, 248.
Properties, effect of small, on population, i. 193.
Proprietors of canals, obligations of, ii. 291.
Protective regulations, various, ii. 308.
—— distance between water-courses in Lombardy, ii. 168, 206—in Piedmont, 295-300—in India, 300, 339, 344, 346, 349.
—— zones (rice culture), ii. 222-224, 225, 226, 321 *et seq.*, 359.
Punchâyut (of India), i. 404; ii. 219.
Punishments for crimes bearing on hydraulic works, ii. 316.
Punjaub, projected irrigation of, i. 395, 397; ii. 235.
Pusiano Lake, i. 164, 173, 243; ii. 190.
Puthri River (India), i. 372.

Q

Quadretto of Verona and Mantua, ii. 35, 161, 212—of Brescia, 32, 33.
Quantity, distribution by, ii. 281.
Quartirola (grass after growth), ii. 78.

R

Rafts, revenue from transit of, i. 321, 322, 342.
Raggia (or levelling machine), ii. 93.
Raipoor Torrent, i. 311, 336.
Rajbuha system, i. 326, 337; ii. 59, 60, 218, 219, 340, 342.
Rajpoor Canal, i. 351; ii. 336, 343.
Ratio of irrigated surface in Lombardy, i. 296.
Redefosso of Milan, i. 198, 272.
Reforms, resistance to, i. 212-213, 249; ii. 197.
Regulating bridges, i. 275—sluices, 17, 21.
—— establishments, 19, 223, &c.
Regulation of navigation, i. 223—of irrigation, law for the, ii. 144.
Regulator of Cigliano Canal, i. 17 — of Ivrea Canal, 211—of Muzza Canal, 63.
Rent (land), in Lombardy, i. 42—effect of irrigation on, 158, 228, 288, 295, 297 — rent-free alienations of water, 136, 137, 139, 146, 147, 158, 206, 232 —rent-free tenures, 428. See *Water-Rent.*
Repairs of Canals, i. 207, 274—done by contract, 253; ii. 177 — under Olona Association, 181. See *Cost of Maintenance.*
Reports, annual canal (Piedmont), ii. 312.
Representative system in development of irrigation, ii. 218.
Retrogression of levels on East Jumna Canal, i. 334.
Revenue from canals, i. 158, 241, 278, (Indian), 318-325, 340-345, 351, 379.
Revetments, i. 113, 223, 230, 239, 272-273.
Rice cultivation, i. 25, 124, 294, 296; ii. 100-106, 320 — irrigation of, i. 30; ii. 101-103, 166—produce and returns, 104, 105 — introduction of, into Europe, 221—insalubrity of, 220-222, 233, 319—prohibition of, and licences for, 222, 321 — regulation of, in Lombardy, 225—in Piedmont, 318-328 — limitation of, 200, 205, 211, 222-224, 321-325—Giovanetti's general remarks on, 331.
Rice-cleaning machines, i. 23—mills, 30; ii. 104.
Richelmy, Professor, i. 12, 15.
Riconsegna, i. 52.
Rights. See *Passage.*
Risaje da Zappa, ii. 100—*da vicenda*, 101.
Risone (rice in husk), ii. 102, 104.
River channels, protection of, ii. 304.
Rivers of Piedmont, i. 91—of Lombardy, 169—table, 186 — irrigation, draft on, 298—of N.W. India, effect of canal abstraction on, 386-388.
Rodigine d'acqua, i. 206; ii. 10, 45.
Roggetta, ii. 91.
Roggia (term applied to irrigating channels), i. 100, 135, 137, &c.
—— *adacquatrice*, ii. 91.
Rohilkund (India), ii. 337.
Romangnosi, works on irrigation and its legislation, i. 58; ii. 153, 300.
Roman names extant in Lombardy, i. 42.
—— law regarding property in rivers, ii. 132.
—— jurisprudence, fragments of, ii. 118, 124.
Rome, i. 80.
Rotation, horary. See *H.*
—— of crops, ii. 79, 101.
Rotto, Canal del, i. 16, 18, 100, 129.
Royal Park Canal (Turin), i. 103.
Ruota, i. 109; ii. 10 — of Piedmont, 15, 17—of Novara, 19.
—— *d'acqua* (horary rotation), ii. 66.
Ruspunna River, i. 351.
Ruthmú River, i. 372, 373.

S

Sala Lake, i. 164.
Salaries, i. 121, 122, 274; ii. 239.
Sale of water by Government in Lombardy, i. 40—of surplus water by proprietors, 226—effect of, in Lombardy, ii. 135—not applicable in India, 137.
Salto di gatto, ii. 141.
San Cristoforo, escape of, i. 205.
San Giorgio, tunnels of, i. 112.
Sanitary relations of rice cultivation, i. 26, 27 (see *Rice*)—effects of *colmatage*, or warping, 78 — bearings of irrigation, 394, 431, 432; ii. 354 *et seq.* — legislation in Lombardy, 219 *et seq.*—in Piedmont, 318 *et seq.*—for India, 332. See *Protective Zones, Medical Committee, Malaria.*
Sarca River, i. 167.
Sardinian penal code, ii. 316. See *Charles Albert* and *Piedmont.*
Sartirana Canal, i. 100, 139; ii. 19.
Scagno, ii, 29.
Scalve Valley, i. 165.
Schwartzenberg, Prince Charles, i. 36.
Scolatori (meadow drains), ii. 91. See *Colatori.*
Scrivia River, i. 91.
Sebino Lake, i. 165.
Secchia River, i. 200.
Seikhs, means of tranquillising, i. 397.

Serio, River, i. 178—canals of the, 285—Morto, *ib.*
Servitudes, law of water, ii. 151, 157, 267—extinction of, 303.
Sesia River, i. 89, 91, 100, 157, 158—canals of the, 134-139.
Sesto Calende, i. 67.
Settala, history of Muzza Canal, i. 265.
Sevese River, i. 173, 198, 264, 273; ii. 236—association of the, ii. 237.
Sewage of Milan and sewage irrigation, i. 38, 266, 267, 275; ii. 89, 90, 96, 236.
Sforza, Francesco, ii. 121. See *Ludovico.*
Sforzesca Canal, i. 33, 100, 135, 147, 218.
Sheil, Right Hon. R. L., i. 71.
Silt, deposit of. See *D.*
Siphons, ii. 141—regulation of, 306.
Sitoni opposes Soldata, i. 213.
Slopes of the Piedmontese plain, i. 89—of canals, 111, 123—of the Ticino, 170—Olona, 173 — Lambro, 174—Adda, 177, 279 — its tributaries, 178-9 — Oglio, 180—Mella, 181—Clisio, *ib.*—Mincio, 183—of the Lombard plain, 184—of Naviglio Grande, 218, 220, 223—of Canal of Pavia, 237—of Canal Muzza, 250—of Martesana Canal, 270—of Naviglio Interno, 271—of canal beds, 335—of summer meadows, ii. 77—of winter meadows, 91.
Sluices, small, i. 17. Of outlets, see *O*, and *Paratoja.*
Smith, Colonel R., i. 333.
Smith, Captain R. Baird, i. 337, 365 (the author).
Snowy Mountains, economical action of, i. 84, 160, 285, 385.
Soil of Piedmont, i. 93—of Lombardy, 186.
Solani River (India), i. 372—aqueduct, 374.
Solaroli, Baron, i. 32.
Soldati, Giacomo, and his canal reforms, i. 209 *et seq.*, 234—his module, ii. 21, 27, 31, 46.
Sombe River, i. 307, 315.
Soprano, canal of, i. 152.
Sormani *v.* Cagnola, case of, ii. 153.
Sovata River, i. 75.
Sovereignty payable on canal, i. 106.
Spanish advancement of Italian irrigation, i. 202, 234; ii. 125.
Special services, water contracts for, ii. 285, 340, 347.
Spinone Lake, i. 166.
Spleen as a criterion in sanitary statistics of irrigated country, ii. 355-8.
Springs (*Fontanili,*) irrigation from, i. 33, 45, 61, 148, 186, 292; ii. 88, 89, 90, 108-112—total amount of irrigation from, 112 — signs of existence of, 109—depth of, in Northern Italy, *ib.*—property in, i. 62; ii. 256—effect of, on canals, 112 — impeding course of, 184, 191—right to, in irrigation channels, 289.
Spring-fed canals, i. 148, 153.
Spring-heads, construction of, ii. 110—money value of, 111, 112—laws relating to establishment of, 167, 206.
Spurs, i. 272, 273.
Stealing water, punishment of, ii. 317.
Stone, artificial, i. 19.
Stone-rooms, i. 222.
Strassoldo, Count, i. 37.
Strone River, i. 180.
Stura River (Northern), i. 91—canals from, 103, 104, 154, 158—(Southern), 151—canals from, 151.
Superintendence of canals, &c., in Lombardy, ii. 173.
Superintendents of Indian canals, powers conferred on, ii. 337.
Surplus waters, and right to them, ii. 89, 167, 195, 206, 209, 212, 231, 268, 289, 308. See *Colature.*
Sutherland, Colonel, i. 427.
Swamps along canal, i. 242—on Western Jumna Canal, 316.
Syphons, ii. 141—regulation of, 306.

T

Table of areas of basins, and discharge of Piedmontese irrigating rivers, i. 91.
—— Temperature, rain-fall, and weather in Piedmont, i. 92.
—— Comparative, of population in irrigated and unirrigated districts of Piedmont, i. 95.
—— Comparative, of increase of population in preceding districts, i. 96.
—— Comparative, of married and unmarried in preceding districts, i. 97.
—— Comparative, of numbers to a family in preceding districts, i. 98.
—— Historical and descriptive statistics of canals from the Dora, Stura, and Orco, i. 118.
—— Agricultural and financial statistics of canals from the Dora, Stura, and Orco, i. 119.
—— Historical and descriptive statistics of canals from the Dora-Baltea, i. 132.
—— Agricultural and financial statistics of canals from the Dora-Baltea, i. 133.
—— Historical and descriptive statistics of canals from the Sesia, i. 144.
—— Agricultural and financial statistics of canals from the Sesia, i. 144.

Table of historical and descriptive statistics of canals from the Ticino, i. 149.
—— Agricultural and financial statistics of canals from the Ticino, i. 150.
—— Data regarding lake system of Lombardy, i. 169.
—— Areas of basins and volumes of irrigating rivers of Lombardy, i. 186.
—— Temperature of Lombardy during season of irrigation, i. 188.
—— Atmospheric moisture in Lombardy during season of irrigation, i. 189.
—— Rain-fall and weather in Lombardy during season of irrigation, i. 191.
—— Comparative, of population in certain irrigated and unirrigated districts of Lombardy, i. 193.
—— Population of the provinces of Lombardy, i. 195.
—— Historical and descriptive statistics of canals from the Ticino, i. 244.
—— Agricultural and financial statistics of canals from the Ticino, i. 244.
—— Historical and descriptive statistics of canals from the Adda, i. 282.
—— Agricultural and financial statistics of canals from the Adda, i. 282.
—— Abstract of works on Western Jumna Canals, i. 317.
—— Detailed items of annual revenue on Western Jumna Canals, 318-323.
—— Statement of annual expenditure and revenue on Western Jumna Canals, i. 325.
—— Abstract of establishment on Western Jumna Canals, i. 328.
—— Comparative statement of population and land revenue on the districts of the Delhi division, irrigated and not irrigated, from Western Jumna Canals, i. 329.
—— Annual increase of land revenue due to Western Jumna Canals, i. 332.
—— Abstract of works on the Eastern Jumna Canal, i. 339.
—— Detailed items of annual revenue on the Eastern Jumna Canal, 340-344.
—— Statement of annual expenditure and revenue on the Eastern Jumna Canal, i. 345.
—— Abstract of establishment on Eastern Jumna Canal, i. 347.
—— Comparative statement of population and land revenue in districts of the Meerut division, irrigated and not irrigated, from Eastern Jumna Canal, i. 348.
Table of annual increase of land revenue due to Eastern Jumna Canal, i. 350.
—— Dimensions, spread of water, and irrigated-area of tank embankments in certain villages of Mairwara, i. 420.
—— Increase in number of families, means and revenue, in the above villages, i. 421.
—— Abstract of the whole number of tank embankments in Mairwara, i. 421.
—— Result on the population, government, revenue, &c., of Mairwara, i. 422.
—— Total government revenue of Mairwara from 1835-6 to 1846-7, and aggregate increase in those years, i. 423.
—— Total sums expended by Government on tank embankments in those years, i. 423.
—— Similar, in reference to Ajmeer, i. 429, 430.
—— Absolute volumes of water-measures used in Piedmont, ii. 25.
—— Relative value of the above measures, ii. 26.
—— Volumes of water-measures of Lombardy, ii. 57.
—— Of horary distribution—example, ii. 67.
—— Comparative statement of expenses and returns from irrigated and unirrigated land in Piedmont, ii. 80-82.
—— Expenses and returns on 20 acres *marcite*, ii. 99.
—— Produce per acre of rotation rice land, in Lombardy, ii. 104.
—— Numerical details connected with irrigation in Northern Italy, ii. 107.
—— Tariff of prices of water in the province of Mantua, ii. 216.
Tadini on meadow irrigation, ii. 85.
Tanaro River, i. 91, 151 — canal from, 152.
Tank embankments, ancient, near Delhi, i. 309—in Mairwara, 407-413—formation, 414-419—tabular statements, 420, 421—in Ajmeer, 429.
Tanks, charge for filling, ii. 341, 346.
Tarantola's work on the *Censimento*, i. 50.
Tartarello River, ii. 201.
Tartaro River, i. 184, 294—abuses on, ii. 199—management of, 201.
Taverna, Cavo, i. 67, 278.
—— Count L., i. 67, 278.
Temperature of irrigating water, i. 33, 46; ii. 78, 88, 89, 90.
—— of Piedmont, i. 92—of Lombardy, 188.
Tenant-farmers of Lombardy, i. 47.
—— rights in Lombardy, i. 51-2.

Terdoppio River, i. 89, 91—canal from, 143.
Terrace-walls in fields, i. 408, 409.
Terzuolo (third hay crop), ii. 78.
Theodoric I., i. 87.
Ticinello, the, i. 203.
Ticino River, i. 37, 59, 68, 89, 91, 100, 158, 163—description, 169, 280, &c. — canals of, 34, 145, 170, 199, 203-242.
Tidone River, i. 91.
Time, distribution regulated by, ii. 281, 286.
Tinelli, i. 45.
Tione River, i. 184, 294.
Toccia River, i. 162.
Tonse River, i. 351.
Torbido canal, ii. 11.
Torricellian Theorem, ii. 37.
Toscolano River, i. 167.
Transit duties. See *Navigation*.
Trees, effect of, on rice crops, ii. 102—regulations regarding, 184, 192, 203, 208, 309.
Tregnone River, i. 184.
Tresa River, i. 163.
Trezzo, i. 64.
Treviglio, i. 63.
Tromba coperta, ii. 50—*scoperta*, 51.
Tuccares, ii. 340. See *Advances*.
Tunnels, i. 108, 112.
Turin, i. 8 — climate, 9, 68 — canals of, 103.
Tuscan marshes, i. 71 *et seq*.

U

Ugoni, Signor F., i. 63; ii. 32.
Unit of water-measure, Piedmontese, ii. 7—for India, importance of, 8, 352—discussed, 60. See *Modulo* and *Measure*.
Use, distribution of water according to, ii. 280, 286.
Utility, compulsory cession of property for works of, ii. 274 — canals of a certain class declared to be such, 277.

V

Val Tellina, i. 164—d'Ossola, 163 — Camonica, 165—Cavallina, 166—Sabbia, 166, 181—Trumpia, 180.
Valley of Ledro, i. 167—of Vesta, *ib*.
Valperga, Counts, i. 106.
Value of water, i. 45, 256 (see *Price*)—of water utilised in Piedmont, 158—in Lombardy, 297 — in the Po valley, 299—of irrigated land in Piedmont, 110—of irrigated land in the Milanese, ii. 83—of produce created by irrigation, i. 319, 320, 340, 381, 430, 431.
Varese, the, i. 67, 172—lakes of, 162.
Variations from normal *modulo*, ii. 53.
Vatican, geographical painting in the, i. 75.
Vecchabia. See *Vett*.
Velocity of Piedmontese canals, great, ii. 23.
Veneria Reale, canals of the (Turin), i. 103, 104.
Venetian irrigation statutes, ii. 121-123.
Vercelli, province of, i. 15, 28, 33, &c.
Verification of pressure in outlets, ii. 50.
Verona, i. 60—water-measures of, ii. 35.
Verri (historian), i. 206; ii. 117.
Vettabia at Milan, i. 37, 173, 197, 199, 275; ii. 88, 236.
Victor Amadeo II., ii. 125, 323.
———— III., i. 110, 128.
Virgil, quoted, i. 86.
Visconti, dukes of Milan, i. 205-6-7, 233, 246, 258, 260, 261; ii. 120.

W

War, use of canal supply in, i. 204.
Warping, process of, i. 76. See *Colmatage*.
Waste lands, reclamation of (see *Maremma*), in Mairwara, i. 408, 421, 432.
Waste of water, ii. 183, 189, 209, 339.
Water, total utilised in Piedmont, i. 158—in Lombardy, 297—in the Po valley, 299—consumption of, by different crops, ii. 61—experiments on the subject in Italy few, 62 — and desirable for India, 61, 62—quantity required for summer meadows, 83, 84, 86—for *marcite*, 96 — for rice cultivation, 106.
—— Effect of deficient, on the habits of the people (India), i. 405-7.
—— Supply of Milan, i. 198.
Water-courses, measurement for village (India), ii. 64.
Water-measures, various, of Piedmont, ii. 25—of Lombardy, 57—for India, 58, 62. See *Modulo, Measure, Unit*, &c.
Water-rent paid in kind, 30, 31, 125—forms of payment, ii. 142, 164, 214—redemption of, 165, 214—remission of, 293—farmed out, i. 30, 31, 120, 206—on Indian canals, i. 318, 340; ii. 334, 338, 343, 344 — contracts for, 338 — defaulters in, 340—remission of, 350. See *Price, Sale*, &c.

Weaving in upper districts of Lombardy, i. 193.
Weirs, regulating, i. 63, 65—of the Naviglio Grande, 221—Muzza Canal, 252—in Mairwara, 419, 422.
Wells, irrigation from, compared with canal irrigation, i. 382—in Mairwara, 419, 422.
Whiting, Lieutenant F., ii. 337.
Winter irrigation in Italy, laws affecting, ii. 140, 142. See *Marcite*.
Ximenes, Padre L., i. 74, 75.
Yule, Lieutenant H., i. 306, 307, 337.
Zabita Khan, i. 312.
Zilladara, i. 327.

THE END.

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